SEWAGE DISPOSAL IN THE UNITED KINGDOM

LEMMOIN CANNON

SEWAGE DISPOSAL
IN THE UNITED KINGDOM

A TEXTBOOK ON

SEWAGE DISPOSAL IN THE UNITED KINGDOM

BY

HENRY LEMMOIN-CANNON, P.A.S.I., ETC.

AUTHOR OF "THE SANITARY INSPECTOR'S GUIDE"; "MODERN SEWAGE DISPOSAL: A POPULAR HANDBOOK," ETC.

WITH A FOREWORD BY

SIR ALEXANDER STENNING

PRESIDENT OF THE SURVEYOR'S INSTITUTION, 1909-10

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FOREWORD

BY SIR ALEXANDER STENNING.

" I have read with considerable interest the manuscript of Mr. Lemmoin-Cannon's 'Textbook on Sewage Disposal in the United Kingdom.' The work not only contains a great deal of information on the subject, but gives evidence of a knowledge of detail concerning the matters with which it deals, put together in a practical manner, which should prove of value to students and others, either as Surveyors or Engineers. .

" It is within my knowledge that the Author was suffering under the greatest physical disadvantages at the time the book was written, and my admiration for the courage which surmounted all difficulties. together with my conviction that the work will prove a useful one, induce me to recommend it as a reliable textbook for those called upon to study this special subject.

" ALEX. R. STENNING."

SUPPLIERS TO ROYAL RESIDENCES.
BALMORAL CASTLE, MAR LODGE, WINDSOR CASTLE, CLAREMONT, ESHER, SURREY.

PREFACE.

In the following pages the author has endeavoured to give a brief yet comprehensive outline of the present position in regard to the question of sewage disposal. It has been a task of no little difficulty to compress within the limits of 320 pages all the information which might appropriately find a place in such a treatise, but although it has been necessary to deal with many of the various topics in a concise manner, every endeavour has been made to present the whole subject in such a way as to make the book useful, not only to those surveyors, sanitary engineers, and local-Government officials who are specially concerned, but also to candidates for the different examinations (including that for the Medical Officer's Diploma in Public Health) in which Sewage Disposal is one of the subjects. The division of the work into short chapters, together with the analytical table of contents, will render it easy of reference, and it is hoped that the Appendices on the Laws of Rivers Pollution, Drains, Sewers, Sewerage, etc., and on the acquisition of lands therefor in England and Wales, Scotland and Ireland, which are additional to the usual matter found in works upon this subject, will be of service to those acting either for public bodies or private owners.

The author has been allowed to exhibit his deep interest in the work of the Benevolent Fund Committee of the Surveyor's Institution by dedicating a moiety of his profits on the sale of this book to the Fund under their charge.

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SEWAGE DISPOSAL IN THE UNITED KINGDOM.

CHAPTER I.

Introduction.

The science of Sewage Disposal, as we understand it to-day, is of quite modern growth; in fact, of the past fifty or sixty years.

In the comparatively high stage of civilization which obtained in some of the later pre-Christian times in Nineveh, and in the early Christian days in Rome, in the height of her culture, some attention was given to the subject of the sewerage of towns. Later, following the decline and fall of the Roman Empire and the dawn of the semi-barbaric ages which succeeded, and well on into the Christian era, we find that sanitation, even in its crudest form, became a lost art; and the middle ages, and even more modern times, did not see its revival. Indeed, it can be safely said that it was not until well into the nineteenth century that any real consideration, on scientific lines, was given to the subject.

Within recent years the efficient disposal of the sewage of communities has gradually come to be looked upon as a subject intimately bound up with public health, if it is not, indeed, the chief factor in sanitary science. As a result, at the present time, some of the best known bacteriologists, chemists, and civil engineering scientists in Britain, the United States, and on the Continent are, and have been for several years past, devoting much time to practical and experimental work in connection with the subject.

These investigations are varied in their character, and are being carried out under all sorts of conditions. If there is any one result accruing from these scientific investigations which stands out more prominently than another, it is the futility of attempting to lay down laws for the treatment of sewage which shall be applicable in every instance. This is due to the fact that features present themselves in one case which are either much modified or are totally different in character to those prevailing in another.*

Although the conditions may be similar at the outset, although, indeed, the crude sewage to be dealt with in one district may be identical in composition with that in another, yet the method of treatment which gave satisfaction in the one case may be most unsuited to the other. This may be due to a variety of reasons, some of which are understood, whilst others still await elucidation. Difference in the nature of the water supply, in dealing with water-borne sewage, or slight differences in climate, or in physical environment, will be, in most instances, sufficient to render a method of treatment suited to one district inoperative in another.

Again, a slight difference in the chemical constituents of a particular water-borne sewage, due to the admission thereto, for instance, of liquid wastes from a brewery, or tannery, or manufacturing process, will probably call for some modification in the method of treatment, before it can be considered to have been satisfactorily dealt with.

Another factor, which has to be considered in the working of every installation, is the change which takes place both in constituents, volume and quality of the sewage to be disposed of in almost every hour of the day.

In installations connected with small towns it is easy also to detect the difference in the composition of the sewage on the chief local washing-day, when the presence of the various chemicals and fats which are used in the manufacture of soap make themselves felt, and interfere very materially with the methods of treatment employed on other occasions, if indeed they do not render it necessary in some way or other to alter or modify the treatment usual on other days.

Half a Century of Improvement.

It is scarcely too much to say, that to the improvements which have taken place in the methods of disposal of sewage matter in towns (the advance has not been so great in country districts) must be attributed a great deal of the improvement in public health which has taken place during the past half-century; and increasing knowledge in its scientific treatment must tend to yet further valuable results in the same direction. Half a century ago serious epidemics were of constant occurrence, and cholera and typhoid, more especially, demanded

* From the opening words of a Paper, by the writer, read before the Institute of Sanitary Engineers, Session 1910-11.

their toll of lives in one part of the country or another. Now, although not yet quite things of the past, as the typhoid epidemics at Maidstone, Gloucester, and Lincoln within recent years have shown, their virulence is much less in comparison.

The decrease in the death-rate furnishes ample evidence of the value of the advance which sanitary science has made during the intervening years, and the advance in the science of sewage treatment and disposal has played no mean part therein.

CHAPTER II.

Nature of Sewage Matter to be dealt with.

This will depend, primarily, upon whether conservancy, or water carriage, is the method employed in the collection of the sewage matter.

In the former, the night soil and urine only have to be dealt with, generally speaking; though, in some cases, house ashes, and, at times, waste vegetable matter are added to the contents of the pails to absorb the urine and facilitate conversion into portable manure.

Under conservancy methods, a system of sewers is necessary to remove the waste waters used for domestic purposes, washings from roofs, roads and streets, and also from stabling; the liquid wastes from slaughter-houses, business premises, and from manufacturing processes, if any.

These manufacturing and trade wastes are very varied in their nature. In most towns they consist of liquid refuse from one or several breweries, which render the treatment of the sewage with which it is mixed more difficult; as do, also, wastes from laundries, on account of the excessive amount of soap and various chemicals employed. Then most towns of any size, and others where leather dressing is a staple industry, possess one or more tanneries, the liquid wastes from which exercise retarding influences on the treatment of the ordinary town sewage with which they are mixed. Lastly, we have the trade effluents from various manufacturing processes, many of which are carried on in particular districts, each of which have special kinds of chemicals, dyes, fats, etc., used therein, as in the Lancashire cotton districts, the Yorkshire woollen and dyeing districts, etc., where such liquid wastes are admitted to the local sewerage system under the Rivers Pollution Prevention Act, 1876.*

In some cases the storm waters and washings from roofs, roads, and streets are conveyed away in separate pipes and receive but little treatment at the sewage works.

It will thus be seen that the composition and strength of the sewage to be dealt with and disposed of will vary to a very large extent in different districts.

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* This Act applies to the United Kingdom (see p. 292).

The chief factors which influence the strength of the sewage are the number of water closets, the number of gallons of water supplied per head of the population of the particular area, and the nature of the liquid trade and manufacturing wastes (if any) to be treated with the ordinary domestic and town sewage.

Amount per Head.

Human excrementitious matter may be considered, by taking an average of all ages, and both sexes, as two to three ounces per head per day, and of urine two pints.

The late well-known chemist, Dr. Meynott Tidy, fixed the quantity of excrementitious matter in sewage, as quoted by Mr. Boulnois several years ago, as follows :—

Every adult male person voids on an average 60 ozs. (3 pints) of urine daily.

The 60 ozs. contain an average of 2.53 ozs. of dry solid matter, consisting of—

Urea	512.4 grains
Extractives (pigment, mucus, uric acid)	169.5 ,,
Salts (chiefly chlorides of sodium and potassium)	450.0 ,,
	1106.9 = 2.53 ozs.

Every adult male person voids about 1750 grains (or 4 ozs.) of fæces daily, of which 75 per cent. is moisture.

The dry fæcal matter passed daily is therefore about 1 oz. per adult head of the population. Of this dry fæces, about 88 per cent. is organic matter (of which six parts are nitrogen); and 12 per cent. inorganic matter (of which 4 parts are phosphoric acid), and some 11 per cent. is soluble in water.

"Other experimentalists give about 35 ozs. of urine and 1½ ozs. of fæcal matter for each person in twenty-four hours, and Messrs. Wolff and Lehmann, from investigations made with a mixed population of 100,000 persons for a year, give the following result:—3 ozs. of fæcal matter, and 26 ozs. of urine per day. It will thus be seen that there is some divergence of opinion as to the average amount of these matters voided daily by an adult, and it is really more important for our purpose to ascertain what is the composition of water-borne sewage. This was given by the Rivers Pollution Commissioners in their first report of 1874, as follows:—

TABLE I.

Dissolved and Suspended Matter in Sewage in Parts per 100,000.

Description.	Matter in Solution.	Suspended Matter.			Total in Solution and Suspension.
	Total Solids.	Mineral.	Organic.	Total.	
Water-closet Towns	72·2	24·18	20·51	44·69	116·89
Midden Towns	82·4	17·81	21·30	39·11	121·51

"This shows that there is, as a rule, only ·116 per cent. of solid matters, in solution and suspension, in water-carried sewage in this country. It must not, however, be forgotten that this solid matter is of an extremely putrescible character, and hence the danger of untreated sewage, especially in cases where there may be in addition large numbers of dangerous pathogenic bacteria, or disease-producing germs."

CHAPTER III.

Conservancy or Dry Systems.

By this title is understood the collection of the dejecta unmixed with water, and either its direct application to garden or other land, such as is usually done in rural districts, or its reception into moveable pails for collection twice or thrice a week, the moveable pails at each house being replaced by empty ones, the contents of the full ones being conveyed to a depôt, there to be dealt with, as we shall notice shortly, for conversion into manure.

Midden Privies—Rural Districts.

In country districts, in the absence of any sewerage system, middens are very common. That it is an insanitary method need scarcely be remarked, and but few words need be devoted to it.

In the curtilage of many a rural cottage the midden is frequently of very unsatisfactory construction, and consequently its contents may percolate into the surrounding soil, with the possibility of contaminating the water supplying a neighbouring well; and, if not, it may possibly vitiate the air in the vicinity and form a breeding ground for flies, now known to be the carriers of many disease germs. Also, it may only be emptied at infrequent intervals, and even allowed to overflow, thus becoming a danger to the health of the residents of the vicinity.

Middens are emptied in two or three ways. A simple, if crude, method is by the use of a ladle. In another, some kind of pump is used. Of the latter there are several useful kinds. Chain pumps which have no valves are most suitable, as they will pump thick liquids.

Midden Privies in Towns.

It was many years, from the time when middens were first used in towns, before their connection with the causation of epidemics of various air and water-borne infectious diseases was understood. This was because the science of epidemiology was practically unknown, and the connection of such diseases with their specific organisms was therefore quite unappreciated. It was many years after before any real steps were taken to do away with these insanitary privies in populous centres, and to employ earth-closets in their place. The change was, however, by no means as satisfactory, sanitarily, as its advocates anticipated.

In this connection it will be sufficient to quote from the experiences of Leicester and Nottingham. The latter city is now one of the rapidly decreasing number of large towns which still, to a very large extent, employ conservancy systems for dealing with the night soil. Leicester and Nottingham are towns in many respects possessing similar features. The former has, however, adopted water-carriage for its sewage in lieu of pail-closets; and it is instructive in this connection to compare the death rate from enteric fever in the two towns.

In 1908, for instance, the death rate in the former was three, whilst in the latter it was eleven per 1000. In the previous ten years the rate was eight and twenty-four respectively. In Nottingham, also, the death rate from the same infectious disease, according to a report of the Medical Officer of Health, in pail and midden closet-houses, as compared with those provided with water-closets, shows a higher incidence, as the following respective figures for 1908 reveal:—

1	case	in	every	185	houses	supplied	with	pail-closets
1	,,	,,	,,	33	,,	,,	,,	midden-closets.
1	,,	,,	,,	198	,,	,,	,,	water-closets.
1	,,	,,	,,	565	,,	,,	,,	waste (slop) closets.

Pail-Closets.

An improvement on the midden privy is what is known as the pail-closet. The earliest of this class was that invented by the Rev. J. M. Moule. Improvements of the same kind of pail are still on the market. This class of pail is usually of galvanised iron.

Fig. 1 illustrates the simplest and cheapest form of pail. It ought to be provided with a tight-fitting lid. Dry earth should preferably be provided in a receptacle in the closet building, and applied to the pail by means of a shovel after each usage, as it helps to deodorise the fæcal matter, and absorb the greater part of the moisture. Besides this method of application by hand, the earth can also be applied automatically from a receptable at the back in the case of a self-acting earth-closet (Fig. 2), with a moveable pail underneath the seat for the reception of the dejecta, and actuated by the movement of the person using it; or in a "pull out" pattern

Fig. 1. Moule's Pail.

(Fig. 3), by means of a handle and lever in the earth-container.

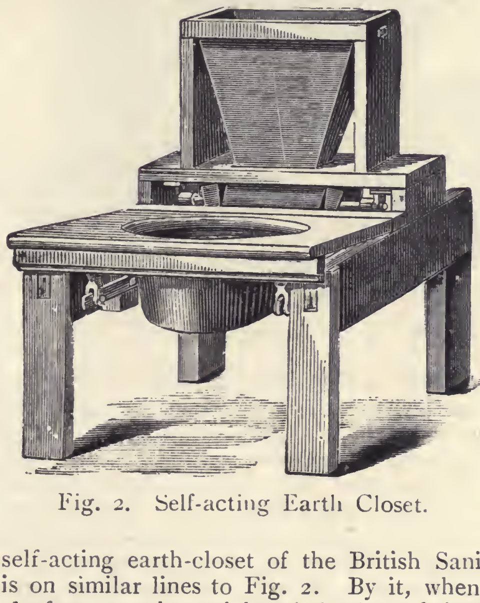

Fig. 2. Self-acting Earth Closet.

The self-acting earth-closet of the British Sanitary Co. (Fig. 4) is on similar lines to Fig. 2. By it, when the seat is relieved after use, the weight of the lever brings out the shovel quickly, thus spreading the earth from the container over the fæcal matter in the pail.

Figs. 5 and 5a show Moule's recent "chucker" action closet, by which the contents of the pail are covered by a simple mechanical contrivance which casts forward a measured quantity of earth. "A" is the reservoir for earth. "B" indicates the earth. "C" is a piece of metal called the "chucker," which comes forward smartly on the user rising from the seat, which movement sweeps the earth off the tray.

Fig. 3. "Pull-out" Earth Closet.

Properly used and attended to, there is much to be said in favour of a dry earth-closet instead of a midden for a cottage or house in a rural district, unconnected with a sewerage system, where even a small garden is available, if the pail is emptied daily, or two or three times weekly, and the contents applied thereto; and provided the closet is not under the same roof as the dwelling, unless cut off from it by a passage with a through current of air.

A tight-fitting lid (not wooden) should be part of every pail if the hygienic side of the question is studied.

It has been considered by authorities on the subject that the contents of the pails should be buried daily, even shallowly; and if applied with care, and the ground cultivated, this method can be productive of nothing but good.

Antiseptics must not, however, be mixed therewith, as such admixture would destroy its fertilising properties and render the ground sterile, besides killing the microbes in the upper layers of the soil which do the work of purifying.

It is interesting to note in this connection that the bacteria in the top layers of the soil play an all-important part in the process of decomposition, which brings about the decay of

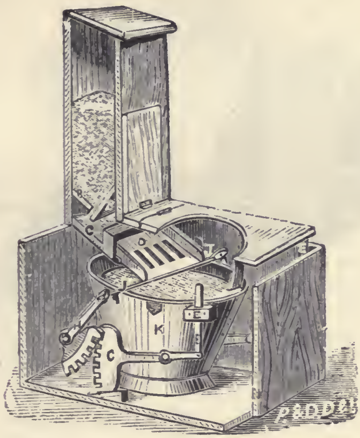

Fig. 4. British Sanitary Co.'s Self-acting Earth Closet.

vegetable matter, whereby it becomes suitable for plant food, thus aiding the growth of vegetation for another year.

The Addition of "Living" Earth.

Certain earth, if applied to the excretal matter in the pails, possesses high "purifying" value.

To ensure this the earth should be slightly moist, and taken from the first few inches of the soil, because it is these top layers which teem with innumerable forms of microscopic life, some of which bring about a process of nitrification, by feeding upon the organic matter in the night soil, and rendering it fit for plant food by reducing it to an inorganic state.

When the pails are emptied, for the same reason, their contents should only be placed just below the surface of the soil to allow the nitrifying organisms the fullest scope for their activity. It is considered that these bacteria gradually decrease in numbers the deeper from the surface, until, after a depth of about four feet, they are practically non-existent.

(This fact accounts for the possible dangers due to the presence of any disease-producing germs in the liquids escaping from a leaky cesspool, for instance, and percolating into some underground source of water supply.)

We shall notice, when dealing with the action of bacteria

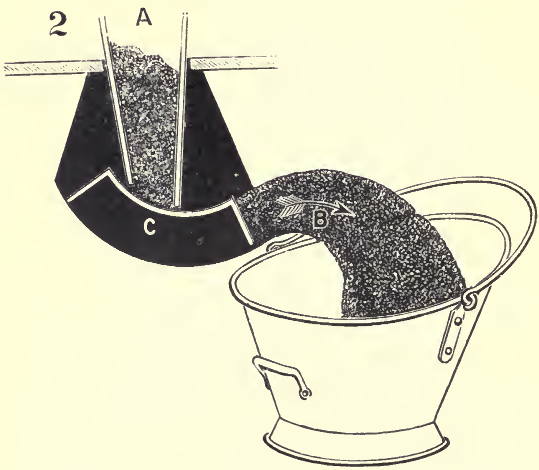

Fig. 5. Moule's "Chucker" Action Closet.

in septic tanks,* the work of this class of organism. Let it suffice to add here that the earth provided for the containers in the closets should be well aerated and not too moist.

Not infrequently ashes, and other dry house refuse, are added to the contents of the pails. Though this may be useful for the purpose of absorbing any moisture, the effective value of either, for the purpose of "purification," is scarcely worth considering, because, in the case of the former, for instance, the action of heat upon the ashes has rendered them sterile, or "dead," and, as a result, the active bacterial life is absent. Again, the absorption of the moisture, which is

* See p. 63.

chiefly urine, reduces the manurial value of the fæces to a very large extent.

In every case the ventilator of the closet should be screened off from flies and the lid of the pail kept tightly closed, because they are fæcal-feeding insects and may convey the specific germs of disease, especially typhoid fever. When it is realised that one fly can carry 100,000 organisms on its six legs, the importance of taking these

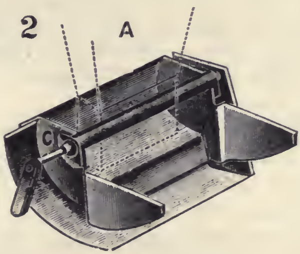

Fig. 5A. Mechanism of Moule's "Chucker" Action Closet.

precautions can be appreciated, especially if we consider the predilection of flies for walking over butter, meat, jam, and other articles of food.

It is a good thing to place a little petroleum in the pail, or to mix it with the earth in the container.

It must be remarked that, from a sanitary point of view, the dry earth or pail-closet system is most unsuitable for towns.

Conversion of Middens to Dry Earth-Closets.

Properly done, this change can be most satisfactorily effected. The seat and floor having been removed, the midden-pit should be cleaned out, the excretal matter which it contains, and which will possibly be found in a semi-liquid condition, carefully removed and applied to land, for which, it need scarcely be remarked, it is an excellent manure.

A quantity of good disinfectant should then be poured into the pit. It should afterwards be filled in with good earth, well rammed. After settling, a floor of concrete, or good hard paving stone, can be laid, with a slight fall to the door.

A wooden seat, arranged for the front or back to be removed, or hinged to fall down, to permit the easy removal of a moveable pail for the purpose of emptying, should complete the work. An ordinary galvanised iron pail or bucket can be used for any of the previously described mechanical or other class of dry earth-closets. Preferably a tight-fitting lid should be made for it.

The pail should be placed under the seat, and should be removed for emptying daily, or at least twice weekly. The contents ought to be dug into land or a garden, one of moderate size being capable of receiving the same without unpleasantness to the occupants of adjacent houses.

It is preferable to apply dry earth to the pail after each usage, and various kinds of pail-closets constructed for this purpose are described elsewhere.*

Disposal of Slop Waters.

Where a dry earth-closet is in use slops and house waste waters ought not to be emptied into the pail, but should be conveyed away from the house and its precincts, either through agricultural drain-pipes with open joints placed underground, which will permit of the liquid percolating into the surrounding earth, or through drain-pipes with properly-made Portland cement joints, whence it is allowed to pass into the earth some distance away, or into an underground storage tank, to be pumped up as needed for garden watering, etc.

Slop-Closets.

In cases where it is difficult to supply water for flushing a closet pan or economy is sought, and the premises are situate in such a position that the arrangement is allowable, the slop water-closet is useful, and can be connected up to a cesspool by drain-pipes.

Figs. 6 and 6a illustrate plan and section of Duckett's automatic slop water-closet, the water for which is supplied from a sink waste. This waste water is discharged into a moveable receptacle, or "tipper," so poised that when full its contents are discharged into the closet basin. A useful flush for the tipper to hold is three gallons.

House slops can also be separately collected in such a tank as Field's, which is a self-acting flush tank. The outlet must be connected with open-joint drain-pipes, laid under garden land, and by flowing out of the joints into the soil the liquid feeds the vegetation. When full the sudden discharge of the tank sends the liquid quickly along the pipes.

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* See p. 8.

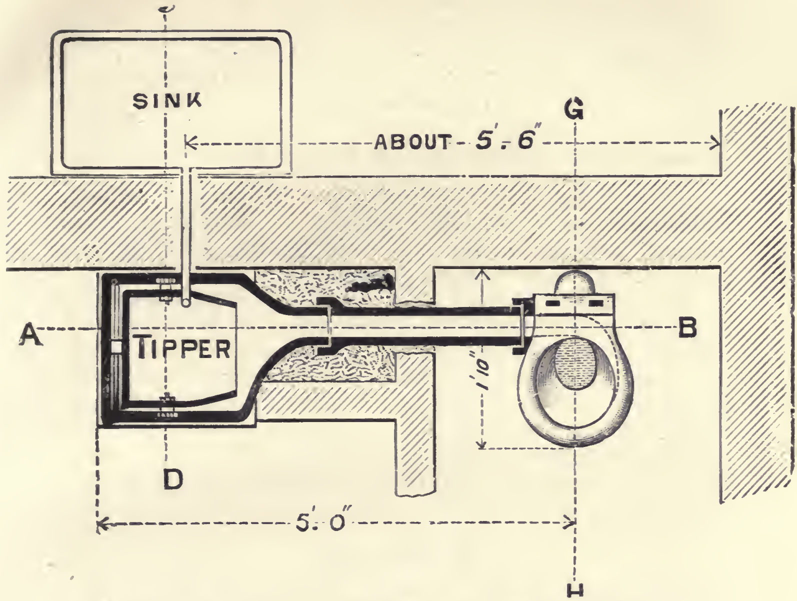

Fig. 6. Plan of Duckett's Slop Water-closet.

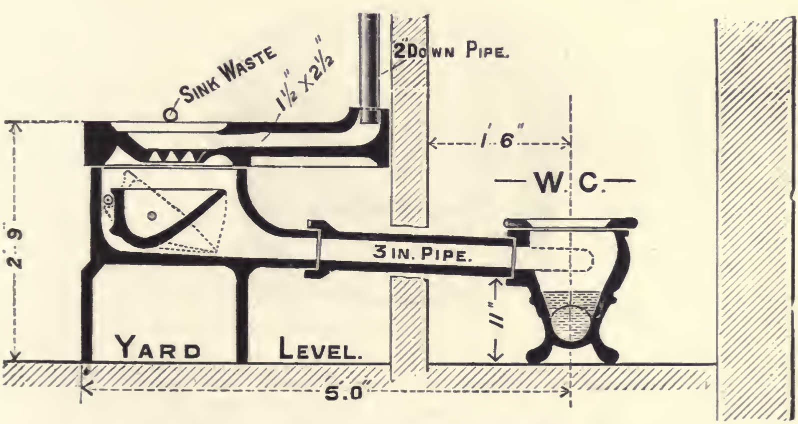

Fig. 6A. Section of Duckett's Slop Water-closet.

CHAPTER IV.

Conservancy, Interception, or Dry Systems in Towns.

Before much attention was given to sanitary matters, midden-pits were usually employed at houses in urban districts, arrangements being made by the local sanitary authorities for their periodical emptying.

But epidemic diseases became of so serious a character that certain scientists devoted their attention to the matter, with the result that moveable pails came into vogue. These were emptied at stated intervals, usually weekly, if not more frequently, by or on behalf of the local authority, their contents being dealt with in bulk. With this class of pail it is customary for householders to add dry earth or dry house ashes, and other dry refuse, to absorb the moisture and deodorise the fæcal matter.

The Gôux Pail.

The Gôux pail (Fig. 7), so-called from its inventor, a Rochdale man, has been used in some manufacturing districts for many years. It is constructed of wood, and bound with iron hoops. Before being sent out from the "treat-

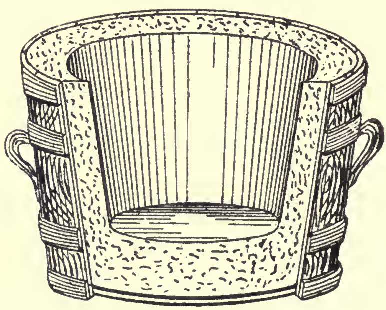

Fig. 7. Gôux Pail.

ment" depôt a mixture of factory waste and sulphate of lime, in certain proportions, is applied to the empty pails after cleansing from the previous use.

A mould (Fig. 7a) is also inserted in the pail, which by pressing the mixture to the sides and bottom of the pail causes it to adhere thereto. This mould is removed when the pail is left in the closet at the house. It is claimed for this mixture that, not only does it absorb the urine and other moisture in the pail, but prevents decomposition and facili-

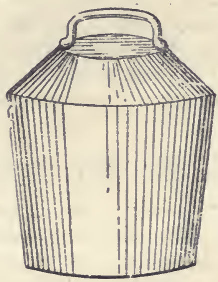

Fig. 7A. Gôux Pail Mould.

tates the treatment of the excreta in bulk for conversion into portable manure.

In conservancy systems there is usually some method of weekly collection of the full pails in suitable vans, either by the local sanitary authority or a contractor employed for the purpose, the used house pail being replaced by an empty clean one.

Conversion into Manure.

The best method of getting rid of these large quantities of excretal matter and general dry house refuse has been all along considered to be to convert the same into portable manure, and then dispose of it to agriculturists on the best terms that can possibly be made. For some time very fair, if not good, prices were realised; but the growth of knowledge in agricultural science in due course demonstrated that its value had been over-estimated, largely on account of the various absorbents which had to be added to it in order to prevent decomposition and to facilitate its conversion into a substance fit for carriage. Therefore, what at first was much sought after has come to be looked upon as only useful if it can be acquired for a mere trifle; and also because it cannot be considered as being in any way as valuable, weight for weight, as artificial, or even farmyard manure.

Stirring Mills.

It will be sufficient to describe in a few words a process of conversion. On the full pails reaching the treatment works, they are emptied of their contents into a large receptacle, and about three times the quantity of dry house refuse is then added. It is next placed in a stirring mill which is then rapidly revolved. A small percentage of sulphate of lime is added, and the mill continues to revolve until the mixture is thoroughly amalgamated, and the moisture practically absorbed. It is then screened to remove any coarser portions, and the residuum is turned into bags for disposal as manure.

Expensive "Dry" Systems.

That conservancy systems are expensive is instanced by the fact that, taking Manchester as an example, it has been calculated that if that city had adopted water-carriage for its sewage in 1892, instead of continuing the conservancy method for several years longer, no less than half-a-million of money would have been saved. Not only is the latter system costly, but the storage of excretal matter in close proximity to houses in towns, though more permissible in rural districts, is insanitary as well, and in those towns, now very numerous, where it has given place to a water-carriage sewerage system, the change has been followed by a decrease in the death rate and general improvement in the health of the inhabitants.

These methods are still in operation in some thirty towns in the United Kingdom. Especially is this so in some of the manufacturing towns of Lancashire and Yorkshire, and the colliery districts. In most of them these methods entirely prevail; in the remainder they are used in conjunction with the water-carriage system.

Reasons for Retention.

Conservancy systems have doubtless been retained in many towns, in lieu of the adoption of the more sanitary water-carriage systems, because of the uncertainty as to what was the best method to install for treating the latter; in others to keep as much water from the excreta proper as possible, to facilitate its disposal by some sort of dry method and sale for manure; and in some on account of the expense of treating the crude sewage which would be incurred by house-owners and the rates if the water-carriage system were adopted. It must, however, be realised that about ninety per cent. of the excrementitious matter itself is composed of water; that farmers and market gardeners are not now so disposed to pay for it, even when converted into manure; that the employment of a staff of men, together with horses and vehicles, is essential for its collection, and that under interception systems in towns, sewers and drains have still to be used to convey away the various waste waters from houses, stabling, slaughter-houses, business, and manufacturing premises, as well as the washings of streets and storm-waters, which, it will readily be seen, cannot be any purer than the human excreta itself. It can, therefore, only be a matter of time before water-carriage for town sewage is generally adopted. In some villages there is now an increasing tendency to collect the human excrementitious matter either in middens or in earth-closets, and then to deal with the house slops, street washings, storm-waters, and general liquid wastes from each community, as is more fully set out elsewhere, by means of a sewerage system, and dealing with the same by some method of land treatment.

Responsibilities of Local Authorities.

Under the Public Health Acts local authorities may either empty the earth-closets, cesspools, or other sanitary conveniences of their districts, or may employ a contractor to do so.

A recent case, wherein an Urban District Council had, under Section 42 of the Public Health (England and Wales) Act, 1875, contracted for the emptying of the cesspools in their district, pending the completion of a drainage scheme, the contractor on occasions had deposited sewage upon plaintiffs' land, in proximity to occupied houses, without permission, thus causing a serious nuisance. Defendant Council did not claim to be entitled to do this, and the only question was whether they were legally responsible for what had been done by their contractor, and consequently liable to damages and costs. It was held that the Council *was* responsible for the disposal of the sewage so as not to cause a nuisance, whether it contracted for the performance of the work or not.

Lord Justice Lindley had laid it down in "Hardaker *v.* Idle District Council" (1896), 1 Q.B. 335, that—"If the contractor performs their duty for them, it is performed by them through him, and they are not responsible for anything more. They are not responsible for his negligence in other respects as they would be if he were their servant. Such negligence is sometimes called casual or collateral negligence. If, on the other hand, their contractor fails to do what it is their duty to do or get done, their duty is not performed, and they are responsible accordingly." In the recent case quoted above, Robinson and another *v.* Beaconsfield Urban District Council. Ch. D., March 15, 1911, Joyce J. decided that the defendant Council had failed to take precautions for preventing damages in carrying out the work contracted for.

The Council appealed to the Higher Court, but it was held that the judgment of Mr. Justice Joyce was right both in principle and on the express terms of the contract, and, consequently, the appeal failed. (Court of Appeal, May 24, 1911.)

CHAPTER V.

Cesspools in Country Districts.

The earliest alteration from the midden-privy, if we except the earth-closet, took the form of the cesspool, which is still employed in connection with many rural cottages and houses remote from a water-carriage sewerage system. These cesspools are usually on the curtilage of the premises in connection with which they are used. A water-closet is employed for the reception of the human dejecta, and this is joined to the cesspool by means of a line of properly jointed pipes, which should be disconnected on reaching the cesspool by a suitable "trap." In cases where the closet is under the same roof as the dwelling-house, or in close proximity to it, or in such a situation that it is not cut off from it by a passage with a through current of air, then even a pail-closet can scarcely be considered sufficiently sanitary, and a water-closet becomes a necessary adjunct to a healthy dwelling.

The closet pan should preferably be flushed by a water cistern, supplied either by some water service, or from a rain-water cistern on the roof with some kind of separator (such as Rogers') to allow the first washings from the roof to pass away. The closet pan can also be flushed by the use of slop water, as previously described,* or a watering-can can be used.

The cesspool should have a water-tight bottom, unless on clay or chalk, when an open bottom is permissible, to allow the fæcal matter to percolate gradually away. (A cesspool with an open bottom, allowing its contents to percolate into the adjoining ground, is not desirable in the vicinity of a water supply, whether in a defined channel above or below the surface of the ground, as there is always a liability of pollution.)

Construction of Cesspool.

The cesspool should be circular in shape, and, after excavation, should have six or nine inches of well-puddled clay applied to the sides and bottom, or at least six inches of Portland cement concrete, finished with a very fine, smooth

* See p. 14.

surface. It should be finished off with an air-tight manhole cover on the ground level, of stone, cement, or iron.

The sides should be made of 4½ brickwork set in and rendered with Portland cement. A ventilating shaft of iron, with a wire cage at the top to prevent birds building there, carried up, say, fifteen feet in the air, is a necessary adjunct, and it is useful to construct the cesspool, if possible, near a tree trunk, for it is a protection to the shaft, and makes it less unsightly.

The size of the cesspool will depend, of course, on the number of persons occupying the dwelling or dwellings in connection with which it is used, the amount of water supplied, and the length of time which is to elapse between each emptying. This latter should not exceed three months.

A smaller one to act as an overflow can be constructed at the side of the main cesspool, as described.

The overflow should be provided in case the main cesspool is not emptied before becoming too full. Instead of a second cesspool, the overflow can be provided for by a pipe leading into the adjacent earth, and carried some little distance away.

The drain-pipe from the dwelling, which should have the joints made with Portland cement, should be trapped at its junction with the cesspool.

Emptying the Cesspool.

This is always a troublesome and usually insanitary process. Various methods are employed for the purpose. Simple means are the use of a ladle or bucket, but it is an offensive procedure. A chain-pump is also useful. Fig. 8 illustrates a single-acting pump suitable for emptying cesspools, etc., and the discharge through the delivery pipe into the cart, or other receptacle, should make such an equipment practically odourless. This pump is by Honig and Mock. Fig. 8a illustrates the sectional detail of valves. The suction valve (a) is a rubber ball; the delivery valve (b) of cast iron with rubber seating has its under side recessed with short guides, as shown, and prevents displacement of the suction valve when the latter is raised from its seat.

An apparatus whereby cesspools can also be emptied in a sanitary manner is made by Messrs. Merryweather and Sons, the well-known fire engineers, of Greenwich. It is on the vacuum principle, and, seeing that its claim to efficacy is dependent upon air-tight conditions prevailing, it follows that there should be an entire absence of nuisance. The principle of the machine (Fig. 9) is that the air in a large tank is exhausted by means of a pump, and, on a valve being opened,

Fig. 8. Honig & Mock's Single-acting Diaphragm Pump.

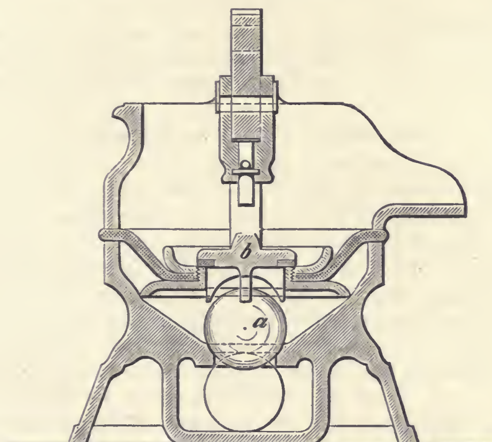

Fig. 8A. Section of Ditto.

the contents of the cesspool are drawn up through special suction piping into the tank. The whole arrangement is mounted on a four-wheeled van for horse draught. A small portable stove is also carried, and the air from the tank is discharged through this, thoroughly deodorising it.

The tank can be made in different sizes, varying from 100 to 500 gallons capacity, and the smaller sizes can be mounted on a two-wheeled van if preferred.

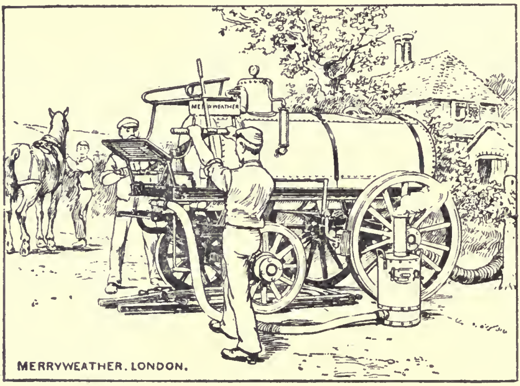

Fig. 9. Merryweather's Cesspool Emptier with Deodorising Stove.

Either of these apparatus should be suited to rural district councils which undertake the emptying of the cesspools of their districts, or to contractors employed by them for that purpose.

Slight Septic Action in Cesspool.

An ordinary cesspool possesses some of the features of a closed septic tank, a system we shall notice more fully in its proper place,* for therein, owing to the exclusion of light and air, certain microbes, known as anærobic bacteria, a species which thrive in the absence of light and air, act in such a manner that the solids in suspension in the sewage are in a large measure precipitated, or thrown down to the bottom of the cesspool, and liquefaction takes place to some extent. But, as the crude sewage matter is held up for much too long a period in the cesspool, and there is, of course, no provision for the passage of the semi-liquified sewage through a channel to which light and air are admitted, and then on to a "contact bed,"† or "percolating filter"‡ (which see in their proper place), very little is done towards the actual purification of the sewage.

* See p. 68. † See p. 72. ‡ See p. 81.

CHAPTER VI.

The Commencement of Scientific Investigation.

Quite early in the last century scientists had been led to think something of the chemistry of the soil, but many years were yet to elapse before any attention was to be devoted to the scientific disposal of sewage, in relation to which, in some way, the soil plays an important part. For several years, however, ere the matter was taken up by the Government, it had been the subject of inquiry by a few interested and scientifically disposed persons, who ultimately succeeded in making their opinions heard.

Early Commissions of Inquiry.

It was not until 1857 that the Government of the day was induced to appoint a Commission to inquire into "the best mode of distributing the sewage of towns and applying it to beneficial and profitable uses." No very satisfactory results being the outcome, a Select Committee of the House of Commons was appointed in 1862 "to inquire into the best means of utilising the sewage of our cities and towns, with a view to the reduction of local taxation and the benefit of agriculture," thus indicating the importance which sewage had been discovered to possess agriculturally. A second Select Committee of the House of Commons was appointed in 1864 to inquire into any plans for dealing with the sewage of the Metropolis and other large towns, with a view to its utilisation for agricultural purposes.

Towns on the banks of rivers and streams, and on the sea coasts, at first discharged their water-borne sewage directly therein, and the state into which rivers and streams were brought by the discharge of this crude matter into them led to scientific investigation being directed to the discovery of some means which should obviate their pollution, and, as a result of the Government taking cognisance of the matter, the first Royal Commission was appointed in 1865 to inquire into the best means of preventing this pollution of rivers. This was followed by a second Royal Commission in 1868. As a result of this investigation it was reported that "rivers which had received sewage, even if that sewage had been purified before its discharge, were not safe sources of potable water."

So important was the subject considered that in 1868 another Royal Commission was appointed to inquire into and report upon the operation and administration of the sanitary laws of places outside the Metropolis, and also included sewage disposal within the scope of the investigations. Yet again, in 1875, the then President of the Local Government Board appointed a committee to inquire into the several modes of treating town sewage. This was followed by the Royal Commission of 1882, to inquire into and report upon the system under which sewage was discharged into the Thames by the Metropolitan Board of Works, whether any evil effects resulted therefrom, and, in that case, what remedies could be applied for remedying or preventing the same. Ever since 1847 London had been discharging its crude water-borne sewage into the Thames, and in hot weather its vicinity became almost unbearable at low tide. Indeed, it was to the hot summer of 1858, and to the neighbourhood of the Houses of Parliament to the Thames, that we are indebted for the Victoria Embankment. "The noble river," said Mr. Disraeli, then Chancellor of the Exchequer, "so long our pride and joy, which has hitherto been associated with the noblest feats of our commerce and the most beautiful passages of our poetry, has really become a Stygian pool, reeking with inevitable and intolerable horrors." And so the Houses, anxious to get away from the river, hastily passed the scheme which eventually developed into the Embankment.

The general conclusions of these Commissions had been that sewage could only be properly purified by land treatment, and as a consequence it has been usual to require local authorities to adopt land treatment, with the result that the "requirements" of the Local Government Boards up to 1908 were that installations for "treating" and "disposing" of water-carried sewage and storm water should be large enough to deal fully with three times the average amount of the dry "weather flow," and less fully with a further equal volume of sewage; and this practically involved the use of land as a *sine qua non*. In May, 1898, the fifth and present Royal Commission was appointed. In 1901 there was issued the first and interim Report, chiefly dealing with the use of land for sewage purification, and which embodied the opinion that there are cases in which the Local Government Boards would be justified in modifying, under proper safeguards, the above-mentioned requirement as regards the application of sewage to land.

In the same Report it was also pointed out that at the time of the earlier Commissions the science of bacteriology was in its infancy; that since they reported, a large amount of exact knowledge had been gained concerning the part played by bacteria in various processes of nature, and under conditions unthought of by man; and that consequently the Commissioners conceived it their duty to study the various questions connected with sewage disposal, not only from a chemical but from a bacteriological point of view.

Practical Results of the Fifth Royal Commission.

This Commission was appointed by the Government on May 7, 1898, briefly to inquire into and report on:—(1) (a) What method or methods of sewage treatment may properly be adopted? (b) If more than one method may be adopted, by what rules should the particular method of treatment be determined? (2) To make any recommendations which may be deemed desirable, having in view the existing law on public health. (3) Economy and efficiency.

When these pages were written, the Commissioners were still sitting, and carrying on a work the objective of which is second to none in its influence on public health. During the existence of the Commission, and up to the writing of these pages, the Commissioners have issued seven voluminous Reports and several Appendices, full of data and information of the highest value to all engaged in sewage treatment and disposal, the results of hearing the evidence of several civil engineers, surveyors, bacteriologists, chemists, and others who have made a special study of that science, and of experiments made on behalf of the Commission.

The writer, speaking in a few words of the results of this work, feels he cannot do better than repeat what he said on a previous occasion in relation thereto:—"The Report, in so far as it throws fresh light on the solution of the problem, is in many respects somewhat disappointing, but, on the other hand, it possesses one or two surprising features. In one way it may be said to do no more than corroborate and lend the weight of the decision of a Royal Commission to the opinions already held by several prominent men who have laboured to elucidate some of the mysteries surrounding the satisfactory treatment of sewage; in another it somewhat depreciates methods which have within recent years been brought into prominence. Yet, the further the Report is looked into the more its value is realised, and the fact appreciated that the decade of the Commission's existence has not been spent in vain. One result has been the modification of the up to then inflexible requirements of the Local Government Boards relating to the construction of sewage treatment installations."*

* "Some Features of the Fifth Report of the Royal Commission on Sewage Disposal (1908)," in Journal of the Royal Sanitary Institute, February, 1909.

CHAPTER VII.

The Water-Carriage of Sewage.

Increase in sanitary knowledge in the latter half of the nineteenth century brought in its train gradual improvement in the methods employed in the collection, treatment and disposal of the sewage of communities, and especially was this so in the case of some large towns. The storage of excrementitious matter, on conservancy principles, in towns came to be looked upon as a highly insanitary procedure, and one productive of considerable danger to the public health. Advanced sanitarians of those days conceived the idea that water-carriage through conduits could be usefully employed in getting rid of the night soil from the precincts of houses, and then discharging their contents in the best available manner away from towns. Some of those towns situated on the banks of rivers, or on the sea coast, seemed to possess suitable facilities for this purpose, and some few of them first took advantage of water-carriage.

Drains and Sewers.

Essential features of this system are house water-closets connected with drain-pipes running therefrom, and thence to the general town sewerage system. At first neither pipe-drains nor sewers were constructed with that care which is now considered to be an essential feature of the proper execution of the work. Both drains and sewers were then usually constructed of bricks, and the former especially were generally much too large for their purpose; and when earthenware pipe drains came into vogue, and any joints were made, clay was used for the purpose, becoming leaky in most cases not long after they were made. It was many years before the present method of making the joints air and water tight, by the employment of cement, came into general and then into compulsory use.

Discharge of Crude Sewage into Neighbouring Waters.

Many towns which were situated on the sea coast, or on the bank of rivers and estuaries, looked upon their positions as eminently suitable for speedily and easily getting rid of their sewage by using water-carriage. The former had the outlets of their sewerage systems on the sea shore, the latter on the banks of the adjacent waters. The seaboard towns reaped many advantages from this system and their situations, because the enormous volume of sea water diluted the sewage matter, and in most cases the tides washed it clear of the shore, though in some cases neighbouring coasts were detrimentally affected thereby.

Riverside towns, on the other hand, created considerable nuisance at the point of discharge of their sewers, which was not good for the healthfulness of the district; and communities lower down the banks, and especially those drawing their water supplies from the same stream, ran grave risks, and from time to time were subjected to serious epidemics of some water-borne infectious disease, due to the presence of pathogenic (disease-producing) germs in the discharged sewage.

Legislation for the Prevention of Rivers Pollution.

The dangers to health which were directly traceable to the pollution by sewage of water used for dietetic purposes, or through nuisances which arose from its discharge into non-potable waters, led to a Section (17) being inserted in the Public Health Act, 1875, upon which may be said to be based the present-day compulsory treatment by local authorities of crude sewage in England and Wales.* Under it a local authority is supposed to free all sewage or filthy water from all excrementitious matter prior to its discharge into any stream, watercourse, canal, pond, or lake.

This section was not only in advance of the sanitary knowledge of that time, but also of present scientific knowledge on the subject. in that it required the crude sewage to be freed from *all* excrementitious matter; it did not, however, place any restrictions upon private individuals, manufacturers, and others. Accordingly, the Rivers Pollution Prevention Act, 1876,† was passed to prohibit any private individual, manufacturer, or mine-owner from discharging sewage or other noxious matter into any such stream, watercourse, etc. (Sections 3 to 7); and further, by Section 20, defined "stream" for the purposes of the Act, to mean and include "the sea to such extent, and tidal waters to such point, as may, after local inquiry and on sanitary grounds,

* Section 19 of the Public Health (Ireland) Act, 1878.

† This Act (1876) applies to the United Kingdom.

be determined by the Local Government Board by Order. . . . Save as aforesaid, it includes rivers, streams, canals, lakes, and watercourses, other than watercourses at the passing of this Act mainly used as sewers, and emptying directly into the sea or tidal waters, which have not been determined to be streams within the meaning of this Act by such Order as aforesaid."

In view of the fact, however, that scientific knowledge prohibited the attainment of the requirements of Section 17 of the 1875 Act, that of 1876 contained a proviso that, to comply with such legislative requirement it is only necessary to use "the best practicable and available means to render harmless such sewage matters or manufacturing or mining pollutions."

CHAPTER VIII.

Sewer Ventilation.

The various Public Health Acts deal with this subject as regards the duties of local authorities to construct and keep the sewers of their district in such a condition as shall prevent them from being either a nuisance, or dangerous, or injurious to public health. The escape of sewer gas is the cause of a good deal of illness from time to time; its properties are highly injurious when the gas is discharged in large quantities into the open air. It is true that the volume of air in itself, and the wind currents, will help to diffuse them, and thus remove very materially a good deal of the danger. Sewer air contains the following principal gases: Carbonic acid gas, methane (marsh gas), hydrogen and nitrogen.

Under Section 19 of the Public Health (England and Wales) Act, 1875, the local authority have to construct, cover, ventilate, and keep the sewers of their district in such a condition that the health of the district is not impaired, and so that nuisances are avoided. As regards Ireland, similar provisions are contained in Sections 17 and 21 of the Public Health (Ireland) Act, 1878; and in Scotland, Section 115 of the Public Health (Scotland) Act, 1897, and Sections 229 and 230 of the Burgh Police (Scotland) Act, 1892, apply, except to Glasgow, Edinburgh, Dundee, Greenock, and Aberdeen, which have special Acts, with power, however, to adopt the Burgh Police Acts.

Ventilation of Sewers.

Ever since sewers have become common for the carriage of water-borne sewage, the question of the dissemination or dilution of the foul gases generated in the system has exercised the minds of surveyors, engineers, medical officers, and chemists. Though by no means satisfactory, it seems certain that the best method to adopt is open ventilation. Very many methods have been adopted from time to time since the years 1830-40. Chemicals have been introduced into the manholes with a view to disinfecting the air passing out in the sewers. Charcoal traps have been similarly introduced. A sewer gas exhauster and destructor was introduced by Mr.

Keeling. His apparatus was very similar to an ordinary lamp-post with a street lamp at the top. The base of the column was connected with the sewer by junction pipes, and the sewer gas passed through to the burner, where it was burned.

The most common method of ventilating the sewers is by the use of untrapped gullies at the sides and in the centres of streets. At the same time this method is far from being satisfactory, and it is preferable to employ tall shafts for the purpose, so that the foul air may pass out of the sewerage system well above the roofs of the houses (Fig. 10). This is, however, a very expensive process, and its employment is for that reason not very general. When in use the shafts are most usually placed at the junctions of streets, where they serve also for fixing street lamps. It has been suggested that the sewers should be ventilated by the upcast shafts on each house drainage system, on the plea that in such a case each house would take its share in getting rid of the foul gases, most of which are generated in house systems. This would, of course, call for the disposal of intercepting traps between sewer and house drains. The pros and cons. of this matter have been debated for many years. Each method has a large following of advocates, but it seems practically certain that the opponents of the suggestion are very much in a majority. The gradients of the sewers and the quantity of the water passing through with the sewage matter proper are factors which have a very considerable influence on the quantity and danger of the foul gases evolved, whilst the sewage is passing through the system on its way to the outfall. Although it is by no means possible, under present conditions, to eliminate altogether the formation of noxious gases, yet where a satisfactory gradient can be given to the sewers by the contour of the streets of the districts, and where there is an adequate water supply to ensure a rapid transit through the sewers, they will of necessity be less pungent and dangerous in their action when admitted to the atmosphere. Where the district to be sewered is flat, an abundance of water to dilute the sewage is a *sine qua non*, and it is also useful to provide here and there large flushing tanks

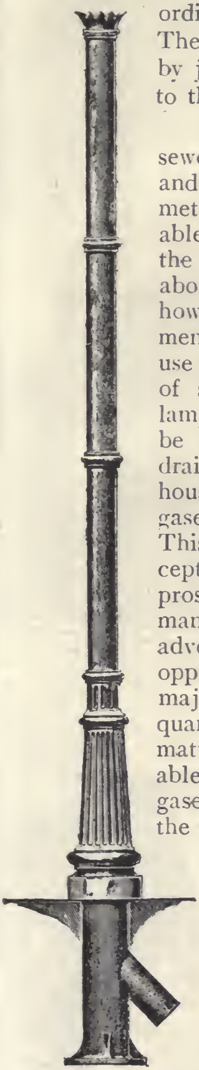

Fig. 10. Sewer Ventilating Shaft.

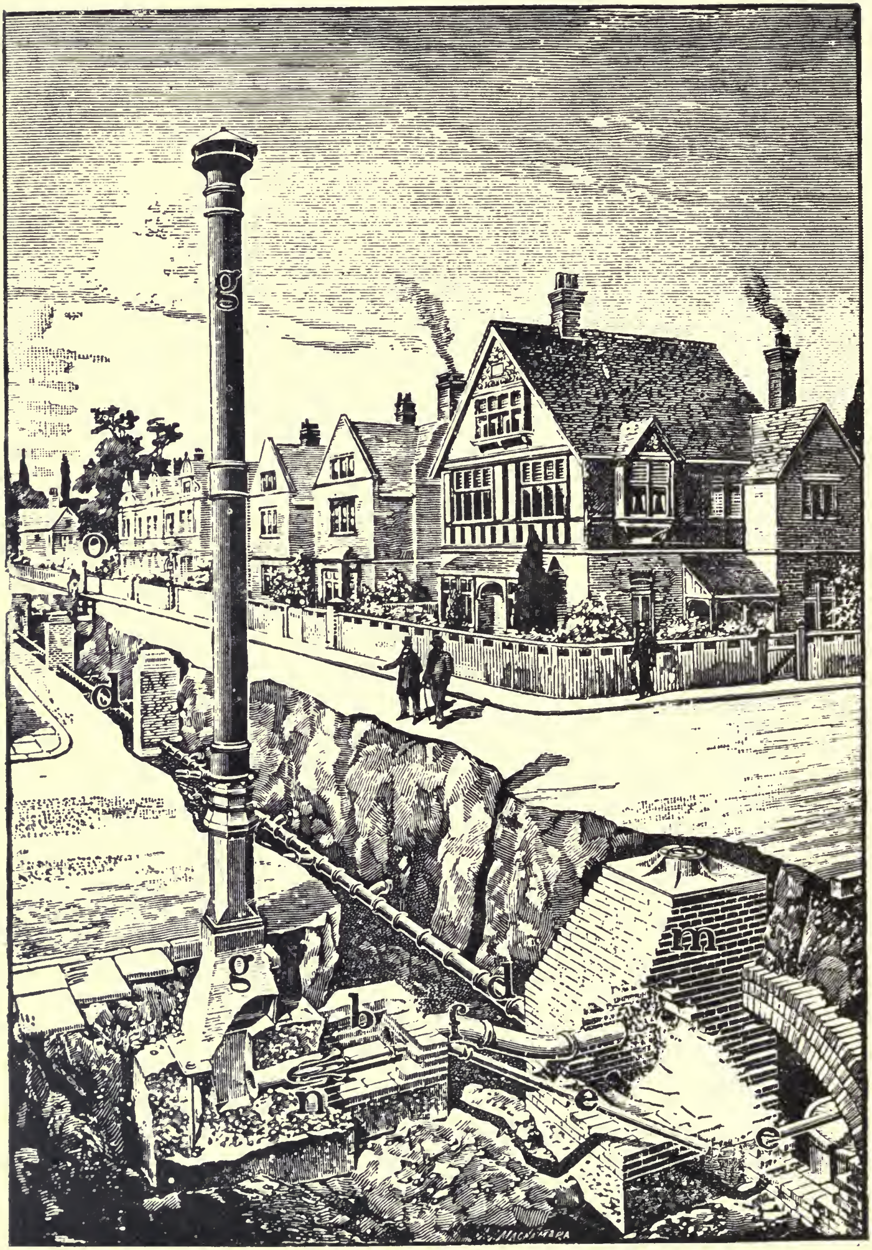

Fig. 11. Shone & Ault's Sewer Ventilating System.

or ejectors both to increase the rate of flow and also to dilute the sewage.

What is known as a self-cleansing velocity in the sewage flow should always be aimed at, because this will prevent the settlement of solid matter, which otherwise is sure to take place, and by being added to, as it would necessarily be from time to time, cause not only a stoppage, but a nuisance, if nothing worse. The shape of the sewer is also a factor for consideration; what is known as the egg-shape formation is a very satisfactory shape in section for the average-sized sewer. Gradients vary, but in most cases it is not wise to have them less than 1 in 100. Where a satisfactory gradient cannot be ensured, some method of retaining the flow at different points and automatically discharging it in bulk, at intervals, is useful for hastening the flow through another section. In some districts the local rainfall may be very large in comparison with others; in the British Isles, this is especially so on the western side and in the Lake Districts. The presence of trees in great quantities, especially on mountain slopes, has also an action in the causation of rainfall. The Eastern Counties, on the other hand, usually suffer more or less from a shortage in average rainfall.

Shone and Ault's Sewer Ventilating System.

Fig. 11 illustrates this system. In it "b" is the ejector chamber, through which the atmospheric air, entering at "o," passes along the sewer, "dd," through the nozzle "n," and up the outlet shaft "g."

The action of filling the ejector by gravitation with the sewage from the sewer causes a partial displacement of the air therein, and it passes along the exhaust pipe "e," to the nozzle "n." The whole operation is worked automatically.

Sewer Ventilation by the Webb System.

The object of this system is to ventilate the sewers as well as to sterilise and deodorise the gas given off therefrom. For this purpose most of the surface manhole sewer grids are closed, and ventilating lamps are substituted for them. They act as sewer gas extractors, and, it is claimed, abolish the sewer gas by consuming it.

Oil lamps can be used for burning up the sewer gases, where coal gas cannot be obtained.

Fig. 12 clearly illustrates the application of this method of sewer ventilation.

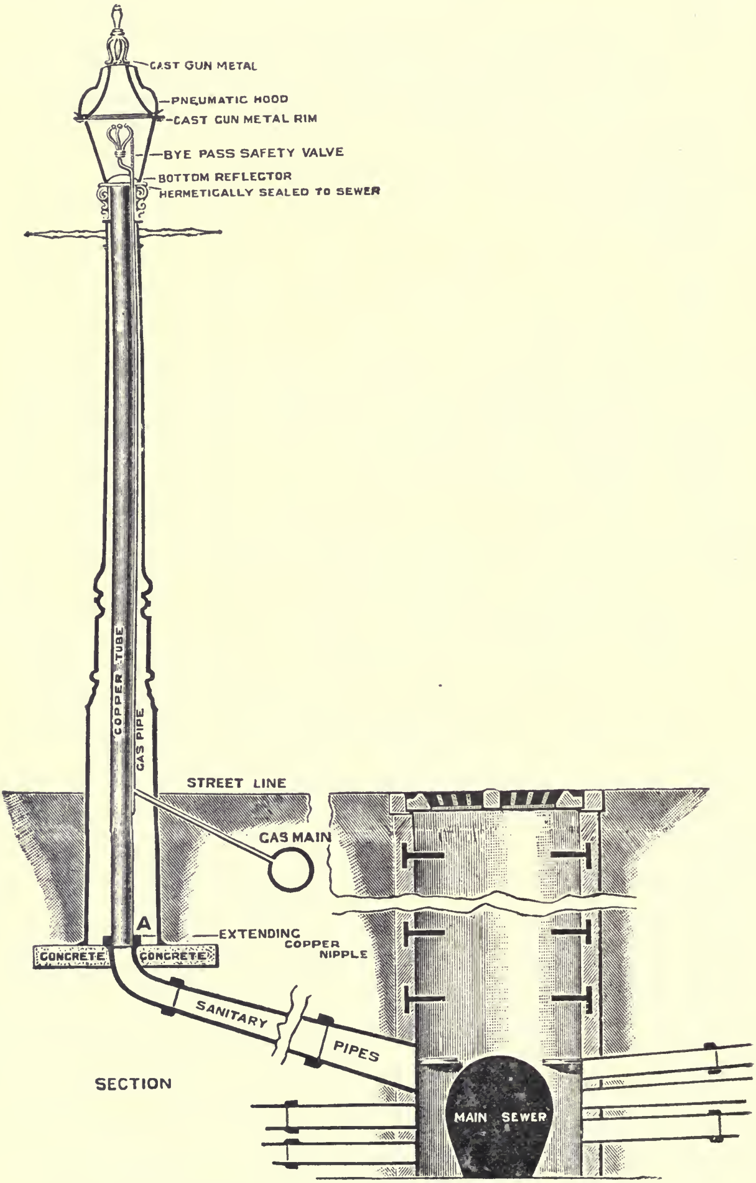

Fig. 12. Section, Webb's System of Sewer Ventilation.

Subsoil Drainage.

In some districts subsoil water has to be dealt with in large quantities, especially where the subsoil is of a porous nature. It will scarcely be necessary to say that the sewers should be so constructed as effectually to debar the entry of subsoil water, for if this can enter some portion of the sewage flow can also escape, and soak into the surrounding earth. Where the porosity of the earth in which the sewer is laid seems to call for it, concrete should be employed in which to bed the conduit. Reinforced concrete possesses valuable properties for such works as these, and is being increasingly used, especially on new systems.

Where there is a good deal of subsoil water to be dealt with, the formation of a separate system of sewers may be called for. These are by no means unmixed blessings, as there is great risk of connection being made to the wrong conduits. Where, however, they exist, the local authority should have power to enforce the provision of separate drains, and their powers should not be limited to new streets and houses.

The Fifth Royal Commission made some reference to this subject in their Fifth Report, but the inference to be drawn therefrom is that the Commissioners were not very favourably impressed with a separate system of sewers.

Where it is necessary to underdrain the site of a house the subsoil drains should be laid at such a depth as will effectually take up both the water settling through the soil, and that present in it. The depth of the outfall to the special sewer, if any, or to the ordinary sewer, must also be considered, and will frequently prevent such subsoil drains being laid more than three or four feet below the basement of the house. The pipes used for this purpose are unglazed with butt joints, and when laid are covered with clinker or rubble.

If the outlet of the subsoil drains is into the sewage drain, it must be disconnected by means of a trap and air-shaft; at the side of the inspection chamber, if any, is a suitable position. To prevent any sewage matter from entering it, the subsoil drain should enter the disconnecting chamber a little above the sewage drain.

CHAPTER IX.

Growth of Disposal by Water-Carriage.

This system is fast superseding conservancy methods of collection, because, in the latter, sewerage systems are equally needed to carry away house slops, road washings, storm waters, liquid trade and manufacturing wastes (if any), etc., and these need subjecting to some sort of treatment as well as the ordinary "dry" excrementitious matter, which latter, as has already been noticed, is a more expensive process, when coupled with the disposal of the various liquid wastes mentioned above, than the disposal of mixed water-borne sewage.

Slight Septic and Mechanical Action in Sewers.

All sewage contains numerous microscopic organisms consisting of many species, and several of these classes are present in the crude water-carried sewage in the sewers; and the meaning and effect of the septic action is that these organisms carry on some work of a preliminary nature during the progress of the sewage through the sewerage system to the outfall. This process is usually spoken of as a septic action, and will be dealt with in some detail elsewhere;* suffice it to remark here that they cause the sewage to become somewhat broken down and slightly emulsified by their work in feeding on and excreting the organic solids which, in so doing, they make simpler in their nature. The extent and effect of this will largely depend upon the distance which the sewage has to travel to the treatment installation.

There is also the mechanical action which takes place in conjunction with the septic one, whereby an additional breaking down of the organic solids takes place by the simple force with which they are driven by the flow of the sewage and by coming in contact with each other, and thus becoming more or less disintegrated and emulsified by being forced and rubbed against each other, which process is described as "mechanical attrition." Lastly, all these effects are simultaneously accompanied by a putrefactive action.

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* See p. 63.

CHAPTER X.

Sewage Farming.

In those places where there were no streams of water into which to discharge the crude water-borne sewage of the neighbourhood, land alone came to be utilized for its disposal; and what has since become known as "sewage farming" appeared to offer the only tangible solution of the difficulty for inland places to resort to. Accordingly, sewage farms were laid out in all directions, to which sewerage outfalls were directed.

The idea underlying this method was the fulfilment of what appeared to be Nature's requirements, viz., that what came "off" the land should be replaced. Thus, if human excreta were replaced, it would only be following this law; because it represents the waste given off from the human system after it has derived nourishment from the vegetable or animal food which it had consumed; the former directly produced from the soil, and the latter drawing its nutrition therefrom.

This process seemed to agricultural chemists a most reasonable solution to the difficulties surrounding sewage treatment, and a proper way to assist Nature in the ordinary cycle of events, and give the land full advantage of the supposed high manurial value of the human dejecta. Hence crude water-borne sewage matter was discharged directly on to farm lands fitted for the reception of the sewage. The land has to be specially prepared by means of levelling and under-drainage to distribute the water-borne sewage evenly over all parts of it, and this is best, and of course most cheaply done, by gravitation from the outfall; otherwise pumping has to be resorted to.

As regards under-draining, it must always be borne in mind that the need for drains depends upon the volume of water-borne sewage liquid to be dealt with per acre, and not merely upon the nature of the soil and subsoil. Where the latter are porous, under-drains are not needed for a moderate quantity. With surface irrigation, under-draining is useful. Suitable crops are grown on sewage farms; of these turnips, oats, rye grass, cabbages, and peppermint usually do well;

though with some classes of sewage the taste comes out in the crops. Live stock are also kept on some farms of this kind.

Financial Disappointments of Sewage Farming.

Advocates of this method of sewage treatment after lengthy experience had ultimately to confess that financial success in sewage farming was unattainable. Owing to the large quantity of liquids of various kinds which accompany the solid excrementitious matter, the manurial value must, of necessity, be weakened by the dilution. A much larger area of land than was at first thought necessary is thus required to deal efficiently with each million gallons of sewage; and this, owing to land values, is a serious expense in the neighbourhood of most towns, and certainly of the large ones; also inability to acquire a sufficiently large area may give rise to serious trouble. The quality of the soil is a most important factor, as unless specially suitable the land is incapable of bearing the strain put upon it, and by receiving more than it can absorb, frequently gets clogged, becoming what is known as "sewage sick." The proper purification of the liquids by the bacteria in the soil which would result if less sewage were applied is thus prevented, and there is a tendency for some of it to be very far from satisfactorily cleansed, and by passing into an adjacent brook or stream in that condition may possibly pollute the waters. Sufficient land must also be acquired to give all portions of it periods of "rest" from the reception of the sewage, for the purpose of aeration.

It must be understood in this connection that no method of treating sewage can be carried out so as to be financially successful. Of those now most usually employed, however, as is more fully shown in the comparison of cost,* land treatment is cheaper, and in every way compares most favourably with them. Bacteriologically, for instance, given suitable conditions, land treatment will very materially reduce the number of bacteria in crude sewage. Again, organic matters present therein can be as well, if not better oxidised, than in other forms of treatment.

Intermittent Downward Filtration.

Experience in various parts of the country with soils and subsoils of varying kinds proved that all could not be relied upon to realise a satisfactory state of purification in crude

* See p. 80.

water-borne sewage, and be used also for the growth of crops. Hence, what became known as the "intermittent downward filtration" of sewage came into use for carrying out this system. The land is prepared as regards under-drainage in a somewhat similar manner for the reception of the crude water-borne sewage as for a sewage farm. But the drainage, which in the latter case may not be deeper than two feet six inches, is usually carried deeper (about eight feet in some cases); and under most circumstances no crops are grown, or, if they are, their growth is made quite a secondary consideration. These latter circumstances permit the surface of the soil being turned over at frequent intervals to revivify it; and, further, by allowing each portion stated periods of "rest" from the reception of the crude sewage, the air is permitted free access to all parts of the soil and subsoil to a sufficient depth, and by these means it oxidizes, or, in other words, burns up those particular organisms which have been destroying the various organic matters in the crude sewage, and so preventing its efficient purification.

The results of practical and experimental works to within the last few years can be summed up in a few words, by saying that experience over a number of years in sewage farming, and intermittent downward filtration, prove that land, unless the soil is of suitable quality and a sufficiently large area is employed, is not capable of efficiently treating crude sewage, so as to ensure a sufficiently high standard of purification. But where these requirements are obtainable, land treatment has undoubted powers of removing pathogenic (disease-producing) organisms, and rendering the effluent harmless; and, further, if the solids are eliminated and the liquids only allowed on the land, a yet higher state of purification can be ensured.

For small towns, where suitable and sufficient cheap land can be acquired in a proper situation, land treatment is of the utmost value.

CHAPTER XI.

Observations at Various Sewage Farms.

The following eight sewage farms were under scientific observation for over two years on behalf of the Fifth Royal Commission on Sewage Disposal, with the object, not only of comparing the land treatment of sewage with various artificial methods, but also with the intent of making various scientific observations which it had not been possible for previous Commissions to make, because of the limitations then imposed on them by the lack of scientific knowledge—viz., the lack of knowledge as to the bacteriological and chemical effect of land treatment on crude water-carried sewage.

In the accompanying Table II. are set out several useful details in connection with the sewage farms under treatment. It will be noticed that the best class of soils are capable of dealing with a much greater proportion of sewage than the others. For instance, the difference between a loamy soil and loam mixed with clay is very apparent, as is also the case with a sandy soil. It does not follow, however, that even the best soils can satisfactorily deal with such a quantity of sewage as that treated at Cambridge. That dealt with at Altrincham cannot be very efficiently disposed of, bearing in mind that the soil is largely peat, it is, however, improved by the presence of sand. At the same time, such soil should, preferably, not deal with domestic sewage from more than 450 persons per acre.

Table II.

Details of Observations at Certain Sewage Farms.

Name of Farm.	Nature of Soil.	Population per acre of land under treatment.	Gallons of Sewage treated per acre per day.	Gallons of Sewage treated per sq. yard per day.	Average depth of under-drains.
Aldershot Camp	Sand	166	8,300	1·72	3 ft. 3 ins.
Croydon (Beddington)	Gravelly Loam	238	9,500	1·96	2 ft. 3 ins.
Nottingham	Light Loam	397	10,750	2·22	7 ft.
Cambridge..........	Ditto	675	30,400	6·28	4 ft. 6 ins.
South Norwood......	Heavy Loam and Clay	138	4,000	0·83	
Leicester............	Ditto	146	5,370	1·11	—
Altrincham..........	Peaty Soil and Sand	514	23,000	4·75	3 ft. 9 ins.
Rugby	Heavy Loam	171	8,500	1·76	say 2 ft.

This Table has been prepared for the benefit of readers, from the details given in the publications issued by the Fifth Royal Commission on Sewage Disposal.

CHAPTER XII.

Land Treatment and Soil Suitability.

One of the most prominent features of sewage disposal is the high value of land treatment, provided the conditions are suitable, even in the face of artificial methods.

The Fifth Royal Commission on Sewage Disposal reported in 1908: "That where the soil is suitable, and the area of land sufficient, the organic matter in sewage can be thoroughly oxidised by land treatment."

We would remark that this confirms the views at one time very generally held. Of course, the investigations of previous Commissions obviously did not deal with the bacteriological aspect, because the work of bacteria in sewage purification was scarcely appreciated a quarter of a century ago. The exact nature of the action which takes place in the oxidation of the organic matters while passing through land (and "filters" also), is still but little known; though enough is understood to show it to be a biological process.

Let us notice the subject of soil suitability from the results of the systematic experiments conducted on behalf of the Fifth Commission at the eight sewage farms, set out in Table II. The soils were varied in character, comprising sand, gravelly, light and heavy loam, heavy loam and clay, peaty soil and sand. Of these, dividing them broadly into three classes, light and gravelly loam seem to occupy the premier position, especially where overlying gravel and sand; heavy loam is placed in the second class; stiff clayey soil, as heavy loam and clay, in the third.

Peat, owing to its spongy nature, is difficult to drain, and is generally not suitable. When, however, it lies upon sand or gravel, the results will be more usually satisfactory. We infer that, in such a case, an acre of land should not deal (with domestic sewage only) with more than that from 450 persons.

Clay will only deal in any way satisfactorily with a proportionately small quantity of sewage, even after settlement; possibly not more than 3,000 gallons per acre per twenty-four hours. In most cases, where clay land only is available, the provision of an installation of artificial filters, following chemical or bacterial treatment, will be found less costly.

Chalk appears to have the least beneficial effect on crude sewage: experiments showed "that apart from the purification effected by the surface soil" (due, of course, to the presence of bacteria therein) sewage underwent comparatively little purification in its passage through about three feet of chalk.

Again, to demonstrate the variations existing in practice "both as regards the method of purification employed and the extent of cropping," the first class of soils is divided into three sub-classes—(a) filtration with cropping, (b) filtration and little cropping, (c) surface irrigation with cropping. In both the other classes, surface irrigation with cropping is the method adopted. Several important details connected with these typical cases are set out in a table, showing (i.) the volume of settled sewage which can be dealt with per acre; and (ii.) the total area of land required to deal with a dry-weather flow of one million gallons, which area, by the way, in conformity with the "Requirements" of the Local Government Board, with slight modification, is deemed sufficient for dealing in times of heavy rains with three times the mean dry-weather flow. In both (i.) and (ii.), sub-class (b) light and gravelly loam, overlying gravel and clay, and the sewage applied by filtration with little "cropping"—25,000 gallons of sewage were dealt with, on forty acres of land, compared with 5,000 and 3,000 gallons, 200 and 334 acres, respectively in Classes II. and III.

Preliminary Treatment.

Where the soil is heavy, preliminary "screening and settling" are useful, before the sewage is discharged on to the land. Preliminary treatment, in such a case, usually consists in removing a considerable proportion of the grit, road detritus, and suspended matter (paper, corks, and often pieces of sticks, cloths, etc.), by passing the crude sewage through coarse screens, which are preferable to those of finer mesh, as they choke much less readily. By this means, oxidation is the better ensured, because aeration of the soil is not interfered with by the possibility of solids accumulating on the land, and forming an impervious layer. Where prior screening is effectively carried out, the area of the land employed need not be nearly so great as where the sewage is applied direct—possibly a third less (or even more in special cases).

Porous sandy soils worked as filtration farms may be able to treat crude, unsettled domestic sewage without detriment;

but, even in these cases, there is the possibility of nuisance arising from the decomposition of sewage solids, on the surface of the soil, and such solids may cause damage to crops. The inference to be drawn is, that preliminary screening and settlement is, in all cases, of value.

Cost and Suitability.

Figures can here be quoted illustrative of the value of good soil and subsoil, not only in the greater quantity of sewage which can be dealt with per acre, but also in the smaller acreage required. Considering land in each of the previously quoted cases to cost £100 per acre (above which, generally speaking, especially where the soil is not well suited, permitting only a relatively smaller quantity to be dealt with, artificial treatment will be less expensive), we notice that the differences in price will be very considerable, the needed area in Class I. sub-class (b), costing £4,000, as compared with £20,000 and £33,400 in Classes II. and III. respectively.

Yet again the initial cost of laying out the land, including levelling, grading, under-drains, carriers, etc., also differs very materially—£4,589, £5,700, and £7,599 respectively. It may here be remarked that under-drainage depends, primarily, on the nature of the soil and subsoil. With a porous soil, like gravelly loam, provided a moderate quantity of sewage only is applied, under-drains are not essential; a larger volume would render them necessary to assist the land to dry off.

CHAPTER XIII.

Land Treatment: Further Facts.

In land purification, especially where crops are grown, and the quantity of sewage dealt with per acre is moderate, the amount of effluent passing off, especially in warm weather, from surface irrigation farms, is very little. This is due partly to absorption by the crops, and partly to evaporation. In artificial methods, on the contrary, there is very little difference in the amount passing into and that discharged from filter-beds, and this is practically due to evaporation.

Qualifying these findings to some extent, it would appear that in the case of some kinds of land, the Commissioners think "that the danger of some of the sewage escaping in an unpurified condition is greater than in the case of artificial filters, assuming equally careful management in each case." Clay lands would come under this category.

Effluents from land of the most suitable character possess fewer micro-organisms than those from artificial filters, though the numbers in the latter can be largely reduced by subsequent sand filtration.

A great loss of nitrogen inevitably takes place, even in land purification, though in a somewhat minor degree to water-borne sewage artificially dealt with. Otherwise than by the agency of plants, nitrate cannot be economically extracted from sewage effluent.

All sewage works are liable to cause a nuisance in their vicinity by giving off unpleasant smells; no proof can be furnished, however, that a well-managed sewage farm is dangerous to health. The huge sewage farm at Berlin (its area is nearly 39,000 acres of sandy soil) may be quoted as an illustration.

Management.

This must always play an important part where sewage farming is carried on. Farm managers have a most difficult part to play, and no amount of care and attention will ever enable land, of any kind, to deal with a volume of sewage which is in excess of the effective purifying area of the soil. "We think it would be useful that farm managers should be taught some simple test, to enable them to follow the operations on the land, and that farming results should be quite secondary to the production of an effluent of the required standard." The latter part of this recommendation of the Commissioners has been very generally accepted as an essential feature of sewage farming for several years past.

It would seem also that more efficient and satisfactory control results from its being exercised by the local authority. In fact, it is considered that sewage farms should not be let.

Factors for Consideration.

In land treatment, to ensure anything approaching satisfactory results, several factors have to be considered; and where these are present it has been proved, as has been just shown, that highly satisfactory results may be looked for.

The principal of these factors are :—

(a) Suitability of soil and subsoil;
(b) Whether or not crops are grown;
(c) The strength of the sewage, and the degree of clarification required in the effluent;
(d) Sufficient area of land;
(e) Suitability of its situation;
(f) Moderation in cost (this must vary with local conditions, but should not exceed £100 per acre).

In case where it is essential to obtain a high-class effluent it might be cheaper to acquire good land at a somewhat higher price in lieu of adopting artificial treatment.

Comparison in Cost of Land Treatment.

In comparing the cost of land treatment with different kinds of soil and subsoil, and methods of treatment and cropping, it should be borne in mind that the comparisons have been to some extent based on the assumptions of the members of the Fifth Royal Commission on Sewage Disposal, from various parts of whose Reports Table III. has been drawn up. As in artificial methods of disposal local circumstances in almost every case govern the cost—to some extent at least.

TABLE III.

Classes of Soils.

CLASS I.—All kinds of good soil and sub-soil, *e.g.*, sandy loam overlaying gravel and sand.

(1) Filtration, with cropping, cost $8\frac{3}{4}$d.*
(2) Filtration, with little cropping, cost $6\frac{3}{4}$d.
(3) Surface irrigation, with cropping, cost $10\frac{1}{2}$d.

* The "cost" is the net annual cost per head of the population draining to the works, based on a daily flow of 33 gallons of crude water-carried sewage, and after deducting the returns from sales of crops, from the gross cost of treatment.

Class II.—Heavy soil overlaying clay subsoil.
Surface irrigation, with cropping, cost 1s. 3¼d.

Class III.—Stiff clayey soil overlaying dense clay.
Surface irrigation, with cropping, cost 1s. 9d.

Table IV. *Comparison in Cost of Land Treatment.*

Class of soil and sub-soil.	Method of Working.	Cost of labour distributing sewage.*	Gross cost of land treatment.†	Return from sale of crops, etc.‡	Total net cost of treatment.¶
	Sub-class.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Class I. All kinds of good soil and sub-soil, *e.g.*, sandy loam overlying gravel and sand.	(a) Filtration with cropping.	0 7 8¾	3 8 0¾	0 6 10¾	3 1 2
	(b) Filtration with little cropping.	0 7 8¾	2 9 9	0 3 3¼	2 6 6
	(c) Surface irrigation with cropping	0 10 9	4 3 9¾	0 11 11	3 11 10½
Class II. Heavy loam	Surface irrigation with cropping	0 13 8½	6 0 8½	0 16 5	5 4 3
Class III. Stiff clayey.	Ditto	0 16 8½	8 11 5½	1 7 5	7 4 0

* The cost of labourers' wages is taken at 21/- per week per man. Roughly speaking, each 40 acres will demand the services of one man for distributing the sewage thereon. This, however, must always depend largely upon the nature of the soil, the contour of the land, the nature of the crops grown, if live stock is kept, etc.

† The total cost includes loan and all other charges, and the cost of the land £100 per acre.

‡ As regards returns from the sales, these may include crops, live stock, and the sludge, and will of necessity vary at different sewage farms. As to what crops are suitable will depend on the nature of the soil and other circumstances. Oats, rye-grass, turnips, cabbages, and peppermint are among those which do well.

¶ This is obtained by deducting the returns from gross cost.

N.B.—The basis of calculation in each class is 1,000,000 gallons of crude water-borne sewage (dry-weather flow), and 30 gallons per head of the population whose sewage is dealt with.

To illustrate the variations in the cost of working sewage farms possessing the above different kinds of soils, and also the variations in returns from the crops, etc., grown thereon, and in the net cost of treatment and other factors, the writer has prepared Tables III. and IV.

The composition of different sewages varies to a large extent at the same "treatment" works. It will vary at times to a very large extent, even hourly. The variations in strength depend chiefly on the amount and nature of the water supply, the proportion of water-closets, and the admission of trade effluents, which retard purification to some extent; especially brewery and tannery wastes.

It will have been noticed that the cost of labour and the total gross and net cost of land treatment, increase in accordance with the degree of unsuitableness of the soil for purification purposes. On the other hand, the opposite result is noticeable in the return from the sale of crops: the most unsatisfactory land for treatment produces the most abundant crops. The comparative lowness of the figures in the three last columns applicable to sub-class (b) of Class I. is, of course, clearly due to the fact that but little "cropping" was carried out.

All the foregoing figures emphasise a common opinion—that a financially successful sewage farm may be considered as almost outside the bounds of practicability.

CHAPTER XIV.

Screening Water-Carried Sewage.

On its reception at the disposal works from the local sewerage system, as will be understood, the sewage contains all kinds of foreign substances, including grit and small stones, from the washing of roads and streets, also corks, pieces of sticks, rags, broken glass, paper, and other objects which have found their way into the sewers, or from some house-drainage systems. If such items are allowed to remain in the sewage, during the process of purification, they will not only tend to retard efficiency, but may even clog some parts of the installation.

The removal of these heavy matters in suspension is a process usually carried out at all up-to-date sewage disposal works preparatory to submitting the water-carried sewage to the particular treatment. Screening the sewage as a preliminary process is usually an economical one.

Tanks, or chambers, are commonly employed for this purpose; so designed that the flow of the incoming sewage through them is such as to allow the before-mentioned foreign substances to settle therein, while allowing the organic solids in suspension to be carried forward.

These tanks are known as "grit" or "detritus" tanks. Their use should always precede sedimentation or septic tank treatment.

At Rochdale the sewage passes from the sewers through a 1½-inch screen and thence into a rectangular grit tank, from whence the heavy suspended matters which settle there are lifted by means of a bucket elevator worked by steam, the contents of which are "tipped" on the works.

That portion (a small one) of the sewage which is to be there septicised, then flows into the septic tank. The remainder, which is to be dealt with by chemical precipitation, is first passed through a second screen, with bars half-an-inch apart, which is raked by steam power.

At York the incoming sewage flows twice through ⅜-inch screens at the works.

The grit chamber is 10 feet 6 inches by 39 feet 6 inches, and 6 feet 6 inches deep, with a capacity of about 17,000 gallons.

At Hendon, on the other hand, there are no grit chambers, but the sewage passes through vertical screens of $\frac{1}{2}$-inch mesh.

In some places, considerable nuisance arises from the screenings, and from the clearance of the grit chambers, which may be effected about once weekly.

Storm Water.

In times of heavy rains a considerable extra quantity of water may come down to the outfall with the excrementitious and other matters comprising the ordinary dry-weather flow. This causes a dilution of the sewage, and at the same time both accelerates and increases its normal flow.

Instead of passing this diluted liquid through the ordinary process of treatment, other methods of disposal are adopted. These depend upon the opinion of the engineer in charge of the works, and may be by means of storm tanks or storm filters.

The first thing to do in this connection is to ascertain the average rainfall spread over a prolonged period and then to provide tank accommodation of one cubic foot for every 35 gallons per 24 hours. Some method should be adopted whereby these tanks can come automatically into operation as required.

In this connection an anonymous writer in the "Surveyor" recently said: "A point which does not seem to have been fully dealt with in print heretofore is the effect on rising mains of the great variation in flow in dry and in wet weather. The minimum flow which should be allowed in rising mains is 3 feet per second, and the writer prefers 6 feet per second, to make certain that no silting occurs, as at 6 feet any scaling is prevented. Again, the Local Government Board have compelled engineers to allow for a rainfall of $\frac{1}{4}$-inch per hour. Taking a normal basis, this will be found to give a total volume equal to twenty times the dry-weather flow in a combined system in residential districts. If there is any considerable length of rising main, it will be seen that it is impossible to allow for both, and at the same time provide a self-cleansing velocity in dry weather, as the friction in the rising mains would be enormous in wet weather. In such a case the writer advises two rising mains, one for dry-weather flow, and one for wet-weather flow."

CHAPTER XV.

Chemical or Antiseptic Treatment.

Following the direct application of crude water-borne sewage to land, and the discovery that all that was hoped of the process was not realised, various experiments were undertaken with a view to eliminating the suspended solids, and thus to deal only with the liquid part of the sewage by passing it over land. Another important feature, which it was sought to place upon a more satisfactory basis, was the destruction of any dangerous organisms, without depriving the sewage of its manurial value. To ensure the latter it was sought to prevent further decomposition in the sewage.

The settlement of the organic solids, preservation of manurial value therein by arresting decomposition, and the production of a satisfactory effluent being then sought, the collection of the sewage at its outfall from the sewerage system was thought of. This necessitated the construction of storage chambers, or tanks, in which this result could be accomplished. With a view to allowing the incoming sewage to gravitate to them, these tanks, which were constructed of brick or concrete, were built in excavations. In these tanks, the floating solids gradually settled to the bottom, but, to increase the rate of settlement and ensure as much as possible the other objects desired, chemicals were also added to the sewage in the tanks as soon as full.

These chemical precipitating agents were thoroughly mixed with the sewage and the whole was then held up for a prolonged period. When the process had produced the settlement desired, the liquid portion of the contents of the tanks was drawn off for discharge into some neighbouring brook or stream. It was, however, soon found that the employment of chemical precipitants was not sufficient to produce a satisfactory top water, or effluent, as it is called, and its passage over land or some other method of further treatment was essential.

The organic solids which were precipitated, as sludge, to the bottom of the settling or sedimentation tanks, had then to be dug out at intervals, and disposed of, and this was soon found to be a matter of considerable difficulty. It has been noticed that advocates of the chemical precipitation of the solids entertained the hope that the resulting "sludge" would not be deprived of its manurial value, and that when dug out of the tanks it would command a ready sale to agriculturists, for the reason that it was thought to possess equal value with the same weight of farmyard manure. These anticipations were by no means realised, because the apparently solid matter was possessed of but little actual solidity; in fact, only some ten per cent. of it might be called true solid matter as regards its manurial value. This must still be looked upon as a much-debated point, and it has been considered a subject of such importance that experiments have been conducted on behalf of the Fifth Royal Commission on Sewage Disposal. These experiments are more fully dealt with elsewhere in these pages.* At the moment of writing they are still being prosecuted, and the results are anticipated to form part of the next reports of the same Commission.

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* See p. 153.

CHAPTER XVI.

Chemical or Antiseptic Systems.
The Chemical Precipitation of Crude Water-carried Sewage.

One of the weak features of the direct application of water-borne sewage to land is the fact that the solids present therein are apt to cause a clogging of the top layers of the soil, and thus not only cause a nuisance, but are also liable from the standpoint of effectual treatment to throw too much work upon the nitrifying bacteria present in the soil. The chief object underlying the application of chemicals to the crude sewage was to break down the organic solids in suspension, so that a greater degree of liquefaction might be ensured, and further, that the process of decomposition which had already started in the sewage might be arrested.

To ensure this it was found necessary to hold up the sewage, on its discharge at the outfall, in fairly large quantities. This necessitated the construction of chambers or tanks, preferably below the ground level, in order that the sewage might gravitate thereto. If the lowness of the district or of the land surrounding the outfall prevented this, some process of pumping became essential.

The periods of time spent in the tanks where chemicals are applied to facilitate the process of precipitation and liquefaction necessarily vary with the powers of the agents employed. Some are much more valuable than others with almost every class of sewage. The application of the most valuable chemicals, however, will by no means produce similar results from the same kinds of sewage at all times, as so many circumstances militate against this. These features are by no means attendant only upon chemically treated sewage, but prevail with practically all classes, and with all methods of treatment.

Chemical or antiseptic processes, though very valuable in many instances, have by no means solved the disposal problem. The ideas that a wholesome effluent or top-water would be produced; that secondary decomposition would be arrested; that dangerous organisms, chiefly those of intestinal derivation, would be destroyed, and that the suspended organic solids would be practically eliminated, have been exploded.

Construction of Chemical Precipitation Tanks.

The crude water-carried sewage flowing from the sewers into the treatment works, even if it has been subjected to screening, or passage through a detritus tank, has yet to gravitate or be pumped into precipitating chambers or tanks if the settlement of the organic solids is to be facilitated by the addition of a chemical precipitant.

These tanks, in their method of construction, present similar features, though their sizes vary with the size of the installation. They may be built in excavation or otherwise.

At the small works at Calverley, where the sewage of a population of some 2,300 is treated, two tanks are used in series. They are rectangular in shape, constructed of brick and cement, with a concrete bottom, and containing one submerged wall in each tank near the outlet end. The size of each tank is 50 feet by 12 feet, with a working depth of 3 feet 2 inches, and a total capacity of 23,500 gallons. At Chorley, where the sewage of 27,000 persons is disposed of, there are eight precipitating tanks, constructed of brick and cement, with a concrete bottom sloping towards the outlet end. The size of each is 90 feet by 48 feet, the average depth 5 feet 3 inches, and the total capacity 120,000 gallons. At Maidstone the two tanks treat the sewage of a population of 34,000, and are also constructed of brick and cement, containing three submerged walls at intervals, with flat bottoms, the side walls meeting them at a curve. Their size is about 158 feet by 28 feet, with an average depth of 4 feet 4 inches, and a capacity of some 1,000,000 gallons each.

At Kingston-on-Thames there are eight precipitation tanks, the size of each of which is 85 feet by 50 feet, with an average working depth of 6 feet, and a capacity of 150,000 gallons. They are constructed of brick and cement, and have bottoms of concrete. A brick and cement wall extends some three-quarters of the entire length, and divides each longitudinally. " Floating arms " are provided, by means of which the supernatant liquor is withdrawn prior to sludging.

A penstock (as Fig. 47) is provided, through which the sewage enters the tanks. It then passes down one division, under two scum-boards, then flows back through the other division, and thence, by means of another penstock, to the entrance tank.

The Dortmund Tank.

At Horfield (Bristol) circular precipitation tanks are used. They are only 12 feet in diameter, but very deep (18 feet), with a capacity of 9,067 gallons each. These are constructed upon the Dortmund plan, being cylindrical to a depth of about 10 feet, and conical from there to the bottom.

The sewage is delivered through a pipe into the centre of the precipitation tank at a depth of 10 feet, and spread by a "bonnet."

The Dortmund tank possesses in some respects distinct advantages over the ordinary rectangular tank, especially as regards the facilities for sludging (i.e., cleaning out the settled solids), and the absence of smell during that process. A deep circular tank of this class is easier and cheaper to cover than a (relatively) shallow rectangular one occupying, as it does, less surface area; on the other hand, however, it is usually more expensive in cost of construction.

CHAPTER XVII.

Methods of Adding Chemicals.

Lime.

To permit the proper mixing of lime with the sewage in the tanks, for the purpose of facilitating precipitation, it should be added in the form of milk of lime, as it is not very soluble in water. To ensure this, the lime, which should be of the purest quality, containing a large proportion

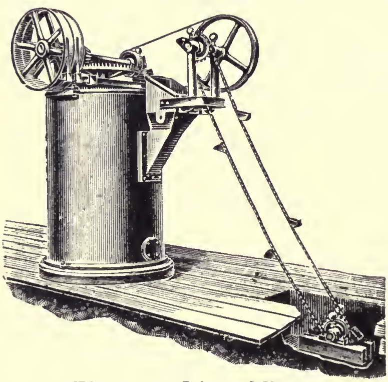

Fig. 13. Lime Mixer.

of calcium, must be well slaked, and reduced to the requisite " milky " condition by the use of a mortar mill or lime-mixer.

Fig. 13 illustrates Manlove Alliot's Lime-Mixer.

The milk of lime should then be added to the sewage in the tanks, preferably by a churning process. The quantity, from three to twelve grains per gallon, varies with different classes of sewage.

Other Chemicals.

With the exception of lime, which, as is noted above, is best added in the form of milk of lime, the most satisfactory way of adding chemicals to crude water-borne sewage in settling tanks, for the purpose of precipitating the organic solids, and as far as possible producing liquefaction, or causing them to settle to the bottom of the tanks, is in the form of a solution, though this method is not always so economical in practice as is the use of the precipitant in solid form.

The use of the precipitant in solution is the most satisfactory method at large installations; but at small works the use of chemicals in blocks ensures economy in labour.

Another simple method, and one practised at Hothfield and Hendon Works among others, is to put the quantity of precipitant (alumina-ferric, in these cases) required for twenty-four hours in a box with false bottom, equivalent to about five grains per gallon of the dry-weather flow, and the chemical is dissolved by allowing water to drip on it.

Yet another method, which, however, is not considered quite as efficient as the above, is to place blocks of the precipitant in the sewage channel, where it is dissolved by the flow of sewage passing over it. In some cases the result is a precipitation of uniform excellence.

A thorough mixture of the chemical with the crude sewage is ensured by the employment of some sort of mechanical means, whereby a churning process is produced immediately after the precipitant has been added.

Favourable Opinions of Chemical Precipitants.

One of the surprises of the 1908 Report of the Royal Commission on Sewage Disposal was undoubtedly the favourable way in which the Commissioners spoke of the value of chemicals for precipitating the organic solids in the tanks, aiding liquefaction, and arresting decomposition.

The opinion of the Commissioners on this point is as follows:—

"There has been a tendency on the part of certain authorities to regard the chemical precipitation of sewage as an obsolete form of preliminary treatment. Our experience in no way justifies this view, and while we are not able to lay down any precise rules as to the particular cases in which chemical precipitation should be adopted, nor as to the relative cost and efficiency of the various precipitants which are available, we think it may be useful to state generally the results of our observations.

"In the case of some sewage, which contains trade waste, it is almost essential to subject the sewage to some form of chemical treatment before attempting to oxidise the organic matter contained in it, and in the case of domestic sewage, chemical precipitation materially aids the disposition of the suspended solids, and facilitates subsequent 'filtration.'"

Chemicals Used.

For the purpose of precipitating the organic matter in the sewage several chemical substances are employed, depending chiefly on the nature of the sewage to be dealt with. These include ferrozone, copperas, lime, sulphuric acid, ferric-sulphate, alumina-ferric (a trade name for iron and alumina), either alone, or in combination with one or more. For domestic sewage of average strength, alumina-ferric, in quantities varying from three to ten grains per gallon of sewage, and upwards, is used in by far the majority of works where chemical precipitants are used. It is very simple in its method of employment, because a given quantity can be added to the incoming sewage, and allowed to dissolve in it.

This compound is also used in combination with other chemical substances, especially where a good deal of liquid wastes from different trade and manufacturing process has to be dealt with. Of some nineteen installations under observation on behalf of the Fifth Royal Commission, alumina-ferric was used alone as the precipitating agent at nine of them. At five others, in combination with lime; at another, in company with sulphuric acid; at another (Kingston-on-Thames) it was used as part of Sillar's A.B.C. process, with alum, blood, charcoal, and clay. The clay used in this method is of a special white kind. Alumina-ferric, used alone for precipitating purposes, acts in a variety of ways with different sewages.

The percentage reduction of suspended matter in the crude sewage is affected by the addition of different chemical precipitants.

At Horfield, near Bristol, where the sewage is domestic in character, and the water supply a rather hard one, alumina-ferric produces a percentage of ninety-three. At Normanton, on the other hand, it only amounted to sixty-seven per cent., with a slop-water sewage, the water supply being a soft moorland one.

As regards alumina-ferric, mixed with lime, the opinion of the same Commission, formed from experiments conducted at Dorking with a sewage of average strength, is that better results are obtained from the combination than when alumina is used alone.

Lime, although not in itself very valuable as a precipitant, is useful in neutralising acids present in the sewage; otherwise it has but little to recommend it, the results being inferior to other chemicals, and owing to the skill required in mixing accurately to fix the quantity of water, the cost of superintending its use is high.

An interesting feature as regards chemical precipitants, and the use of local means as far as possible, is afforded at Buxton, where the local natural iron water is employed with milk of lime.

The A.B.C. process, carried on at Kingston-on-Thames, in which a combination of alumina-ferric, alum, blood, charcoal, and clay is used, and which was spoken of by the Fifth Royal Commission as "undoubtedly a very efficient form of chemical precipitation," produced a higher percentage in the reduction of the suspended solids, as the result of precipitation in the tanks, than from the employment of other chemicals under observation, viz., as much as ninety-five per cent.

With different classes of sewage various kinds of chemical precipitants have to be used; and this is so even with sewages which are similar in character, where the circumstances of each case are different. The addition of large quantities of liquid trade and manufacturing waste calls for special kinds of precipitating agents, or for some modification in the use of others. At Bradford, for instance, sulphuric acid is added to the sewage, which has large quantities of wool-scouring refuse turned into it, for the purpose of separating the fat; this is afterwards extracted from the sludge. In another case, at Burton-on-Trent, large quantities of lime are added to deal with the very large quantities of brewery wastes.

Cost of Chemicals.

Chemical substances, used as precipitants, vary very much in price in different parts of the country, a wide difference being found in the cost of the same precipitants. Alumina-ferric, for instance, has cost on an average £5 6s. per million gallons of sewage at Withnell; £2 2s. at Guildford, and £1 5s. at Normanton.

Alumina, used in combination with lime, costs only about 12s. 8½d. at Friern Barnet.

In each of the above cases the sewage dealt with is very strong in character, and the calculation is based on the dry-weather flow.

At Chorley, where the alumina-ferric is made in the works, the cost is only £1 for the quantity added to each million gallons.

At Kingston-on-Thames the A.B.C. process costs £3 4s., and the natural iron water, combined with milk of lime, used at Buxton, costs only 4s. 6d. for the same quantity.

CHAPTER XVIII.

Settlement of the Suspended Solids by Sedimentation.

Tanks of the same kind, and constructed in a similar manner to those used for chemical precipitation, are used for the purpose of attaining the settlement of the suspended organic solids by sedimentation. All tanks so used are, in reality, sedimentation ones, because, although the methods employed are different, the object is the same—the elimination of as large a proportion as possible of the suspended solids in the crude water-borne sewage, and at the same time the production of as good a top water, or tank effluent, as the particular process will produce, according to the nature of the sewage. Whatever method is employed, solid matter, or sludge, as it is called, settles to the bottom of the tanks. This has to be removed at varying intervals, depending on the means employed to ensure the settlement of the solids, the composition of the particular sewage dealt with, the length of time intervening between the cleansing of the tanks, the nature of the matters in suspension, and the shape of the tanks.

The principal methods employed to produce this sedimentation process are:—Continuous flow settlement with chemicals; the same without the chemicals; quiescent settlement, with and without chemicals; and septic tank treatment.

As regards quiescent settlement, no definite rule can be laid down as to the length of time that should be occupied in dealing with the suspended solids; but with some mixed sewages, such as those containing wool-scouring liquors, two or three hours have proved sufficient to remove a large proportion of the solids entering from the tanks with the crude sewage.

Table V. gives some approximate details as regards the time needed in the tanks to produce sedimentation, the approximate cost of the tanks, and of "settling" 1,000,000 gallons of sewage.*

* See p 70.

CHAPTER XIX.

The Septic and other Bacterial Systems of Sewage Treatment.

These methods are the antithesis of the chemical processes, and are the most recently discovered. As we have noticed in the employment of chemicals for the preliminary process of facilitating the precipitation of the suspended solids, in the crude water-borne sewage, the underlying ideas are to effect such settlement and arrest decomposition in the sewage matter, whilst, at the same time, preserving its manurial value as far as possible; destroying a good many of the pathogenic (disease-producing) organisms; preventing secondary decomposition in the tank effluents; and, as far as can be ensured, the prevention of nuisances on discharge from the tank, and subsequently in the final effluent on its discharge from the works. By the bacterial treatment, however, the decomposition and putrefaction of the sewage is encouraged.

The Use of Natural Agents.

For the purpose of ensuring liquefaction in the crude sewage when it enters the septic tanks, natural agents, in the shape of microscopic organisms, bacteria or microbes, as they are more commonly called, are employed.

These minute forms of life were discovered by the eminent French scientist, Professor Pasteur, and it is from him they obtained the name of microbes, from two Greek words, *micros*, small, and *bios*, life. A good deal of controversy has been waged around the question as to whether these organisms are descended from parents of exactly the same species as themselves, or are the result of spontaneous generation. The writer favours the former theory. The work of these microbes is exceedingly interesting, and they play an all-important part in Nature's marvellous economy. Some exercise exceedingly harmful functions. Of these, the most dangerous are the specific organisms of different infectious diseases, each of which has its particular germ. Thus the tubercle bacillus is the cause of tuberculosis, and the bacillus typhosis of typhoid, or enteric fever. Decay, as a process in Nature, takes place in almost everything around us. To take vegetable life as an illustration. The process of decay in this case is caused by micro-organisms, by means of which decomposition goes on, and vegetable matter is prepared and adapted as the plant food for another year; thus Nature makes use of the same food again and again. Her agents appointed to prepare this refuse matter for plant food are particular species of organisms, so minute that the most powerful microscope is needed to detect them. The chemical composition is altered and simplified by the microbes which carry out this work, by their feeding on the vegetable matter which in due course they excrete. Although the process is by no means thoroughly understood, sufficient is known to determine that several species are employed to carry out this work, and that the life products of one class usually serve as the food of another, each species being killed or poisoned by its own products. Thus to carry on this work several varieties of bacteria are employed, each performing a definite part, only to succumb to its microbic successor. As regards sewage purification, the latest discovery has been that, given suitable conditions, by no means at present thoroughly understood, aided also by suitable apparatus, and possibly by other low forms of life, such as worms and larvæ, micro-organisms can be relied upon to carry out some portion, at all events, of the work. That bacteria could be utilised in any way for the purification of sewage was discovered as the result of investigations by certain French scientists some twenty-five years ago; but it was not until some dozen years since that it first occurred to Mr. Donald Cameron, then City Surveyor of Exeter, to utilise certain definite species for the purpose. When it was suggested the idea was received with considerable scepticism in sewage disposal circles, because micro-organisms had, up to that time, been looked upon almost solely as the cause of various infectious diseases, and also to the fact that their employment was a complete reversal of the methods which had been hitherto followed under chemical treatment.

The idea underlying the employment of the bacteria present in the sewage and their life products was that the organic solids in suspension in the sewage could be "digested" by passing them through a sealed tank, in which putrefactive organisms were encouraged to multiply, and as the system followed the lines employed to bring about decomposition in vegetable matters, as we have noticed above, it seemed a very suitable thing to utilise the natural agencies as far as possible.

The tanks, as first designed, were constructed to exclude light and air by being covered in with roofs. In this way those species of microscopic germs, which thrive in the absence of light and air, and are for that reason known as "anaërobic" bacteria, are employed, and the liquefaction of the solid matter is encouraged thereby. This closed tank is still usually preferred. The sewage enters the tanks below the water level, and those organisms which exist in it, and which have already commenced a process of throwing down the suspended solids in the sewage whilst in the sewers, are encouraged to multiply. The anaërobic bacteria, finding in their new surroundings, absence of light and air, plenty to feed upon, and an equable temperature, multiply with extraordinary rapidity, and give place in due course to successive species which attack the organic solids in the sewage.

These solids are at first either thrown down or rise to the surface, according to their specific gravity, but gradually, owing to the work of the various species of bacteria, some of the solids rise to the top, where their liquefaction is completed.

When the system first came into operation it was claimed that the septic tank was capable of:—(1) Solving the sludge problem, owing to the bacteria therein digesting practically all the solid matter in the tank; (2) of destroying any pathogenic (disease-producing) germs which might be present in the sewage; (3) of ensuring the more easy oxidation of the sewage which had been dealt with in the septic tank than sewage from which the organic solids in suspension had been allowed to settle, either with or without the aid of chemical precipitants, in tanks which were cleaned out at frequent intervals.

From the majority of the evidence given before the Fifth Royal Commission it is clear that in practice all the solids in suspension do not undergo digestion by the bacteria in the septic tanks, and that the amount digested by their aid will depend in many ways on the nature of the tanks, the quantity of sewage dealt with, and the length of time between the periods of cleansing. Coming to the second claim, it would seem that the sewage effluent on its discharge from the tanks is not more bacteriologically pure than when it entered them. As regards the third point, it would appear that an ordinary domestic sewage effluent issuing from a septic tank is not more easily oxidisable than any other tank liquid.

Open septic tanks were next tried, but they have been proved to be of no greater value than closed tanks in this respect.

Reasons for Adopting Bacterial Treatment.

There may be considered to have been two chief reasons for this, in preference to the preliminary treatment by chemical precipitation—

(1) To eliminate to a greater extent the sludge resulting from the addition of chemicals to the sewage in the settling tanks; and

(2) The economy which it was assumed would result from the saving of the cost of disposing of the greater quantity of sludge; from the saving on the chemicals used in that method of treatment; and also, on the outlay for the machinery essential to the process of mixing the chemicals with the sewage.

As we have noticed above, these anticipations have by no means been realised.

Experience has shown that the powers of sewage bacteria, as regards its purification, have been very much over-estimated, and more particularly has this been so in relation to the elimination of the sludge.

When the septic system of preliminary sewage treatment came into vogue, it was thought that settling tanks could be dispensed with, and that instead of using them it would serve the same purpose if the crude water-carried sewage was discharged directly on to the contact beds, where, by the action of the bacteria the sludge could be almost, if not quite, eliminated. This, however, was ere long proved to be economically unworkable, owing to the beds becoming choked through their retaining organic and inorganic matter in an irreducible state.

It is, therefore, now thoroughly realised that the use of the settling tank is absolutely essential to enable the micro-organism present in the sewage to feed upon the organic solids in suspension therein, and to reduce them to a state as highly liquefied as possible; thus continuing, under control, the work already commenced by them whilst the sewage was passing through the sewerage system.

Period in Septic Tanks.

This will depend, to a large extent, upon the nature of the sewage, the length of time which it has spent in the town sewerage system, and the number of gallons of water per head supplied to the population.

The experience of Mr. T. J. Fowler, D.Sc., the eminent sewage chemist, has led him to say that, in case of sewage, where forty gallons of water is allowed per head, twenty-four hours should be given for the settlement of the solids. With a greater flow per head, it can be correspondingly quicker. Despite this, however, as long as forty-eight hours have been occupied with the exceptionally strong domestic sewage at Caterham; 37.7 hours with strong domestic sewage containing a large proportion of brewery refuse, at Guildford; and 31.7 hours at Hartley Witney, with large quantities of wool scourings, etc.

The maximum period should not, however, exceed twenty-four, nor the minimum twelve hours. The rate of flow should aim at setting up a vigorous fermentative action, as this brings about the destruction of much organic matter.

Dr. Fowler has also proved that increase in temperature accelerates this, especially in hot climates such as India.

Other experiences show that by the addition of from two to three grains of lime to each gallon of septic tank effluent, immediately following the treatment therein, not only is its offensive character and consequent risk of nuisance largely reduced, but it is possible by these means to reduce the solids in suspension present in the sewage entering the septic tanks from some eight to five per cent.

Open versus Closed Septic Tanks.

For several years this was a much-debated question, and led to many experiments. Two different classes of bacteria work under these opposite conditions—anaërobic, those which work in the absence of light and air, and aërobic, in the presence of light and air. The results, however, in each case, as regards the purity of the septic tank effluent and the digestion of the sludge, appear to be the same; and the only difference is that open tanks create a great deal of nuisance, owing to the effluvia given off in their vicinity. The degree of nuisance will depend on the nature of the sewage; that containing brewery refuse, for instance, is most objectionable, whilst, on the other hand, the presence of some trade effluents will materially reduce the nuisance created in the process.

CHAPTER XX.

The Construction and Use of Septic Tanks.

Septic tanks are constructed similarly to chemical precipitation or sedimentation tanks, viz., of brick and cement with concrete bottoms. The closed tanks are covered with one or two concrete arches, over which a layer of soil is generally spread.

The tanks are usually built in excavation, and the sewage should preferably enter them below the water-level, so as not to interfere with the working of the liquefying organisms. Where possible the tanks should be constructed in such a position that the sewage may gravitate to them; otherwise it will have to be lifted to them by pumping.

At Andover there are two closed septic tanks, the size of each being 80 feet in length by 16 feet 8 inches in width, the depth of water being 8 feet 6 inches. The tanks hold some 60,400 gallons of sewage each, which enters them from the grit chambers by two inlets placed above the water level. The sewage is pumped before it enters the tanks. It is drawn off the surface through a slotted pipe, laid across the breadth of the tank. An automatic valve, situated in the outlet channel, regulates the outflow of septic tank effluent, and causes the water-level in the tanks to rise and fall.

The tanks are used in parallel. With an approximate continuous dry-weather flow of 150,000 gallons per twenty-four hours, it would give a flow through the tanks at the rate of 83 inches per minute. At the first, the feed channels to the septic tanks were open, and caused a deal of nuisance, but these are now closed in, and the nuisance has practically ceased.

At Prestolee* (Bury Rural District Council) the single septic tank is a simple rectangular chamber, 36 feet by 10 feet, with a 7 feet depth of water, and a capacity of 16,625 gallons. It is contructed of brick and cement walls, with a concrete bottom. The tank is a closed one, being covered over with a brick arch, over which a layer of soil is spread.

Into this tank the whole of the day and night sewage is discharged. It enters at the water-level through a single inlet passage, and issues (also at the water-level) through a pipe

* See p. 203.

placed at one of the extreme corners of the outlet end, which is protected by a scum-board.

Based on a dry-weather flow of 18,000 gallons per twenty-four hours, the flow through is once in twenty-two hours, at the rate of 34 inches per minute.

Description of Early Septic Tanks.

The tanks, as first used, to encourage the putrefaction of the crude sewage, whereby the micro-organisms of decomposition speedily multiply, were originally designed to exclude both light and air; for it had then been found that the liquefaction of the solid matter in suspension was best effected by permitting the propagation of that class of bacteria known as "anaërobic," or, in other words, that species which thrives in the absence of air and light; for at that time it had not been fully realised that "aërobic" bacteria could equally perform the work in open tanks, they being of the class suited to carry out the same work in light and air. Closed tanks, however, are still to be preferred, owing to the absence of nuisance from smell.

The Choice of Tanks as a Preliminary Treatment for Various Classes of Sewage.

This will depend chiefly on the method to be followed in disposing of the tank sludge; also upon the nature of the filtering material to be used for the oxidisation of the effluent from the sedimentation or septic tank, whichever is used for eliminating the suspended solids in the crude water-carried sewage, and upon the nature of the water supply, whether temporarily or permanently hard, moorland, peaty, or otherwise.

Classes of Domestic Sewage.

Domestic sewages are divisible into three classes, depending on their strength—very strong, average strength, and weak—and in every case manufacturing and trade wastes of various kinds may be mixed therewith.

Very strong water-carried sewages, containing a considerable quantity of solids in suspension, generally speaking, lend themselves more readily to chemical precipitation as a preliminary process, in preference to such solids being broken down by septic tank action and settlement of the sludge.

Chemically treated sewage sludge is also less costly to press into cakes by sludge-pressing machinery than that which is septicised; especially is this so where lime has to be added in large quantities to assist the pressing process.

Where average strength domestic sewages are concerned, local circumstances and the kind of contact bed or filter to be used to oxidise the tank effluent should determine the preliminary process—whether chemical precipitation or septic tank—to be employed; and the same results may be ensured by chemicals used as precipitants, or sedimentation, or septic tank.

Where weak domestic sewages have to be dealt with, septic tank treatment, or sedimentation, is most suitable, especially if land can be secured at a moderate cost for the purpose of burying the tank sludge, which, under these circumstances, would not have a very offensive smell.

It must be borne in mind that sewage from the same town may vary very much from time to time in strength and character, and may require some modification in the method of treatment. Under such circumstances the septic tank has a valuable equalising effect.

As regards the preliminary treatment of sewage, and the same may be said of the whole method of disposal, using the words of the Royal Commissioners: "It is by no means to be thought that finality has been reached in sewage treatment and disposal."

It has been definitely ascertained, however, that bacteria are the natural agents chiefly employed in bringing about the indirect oxidation of sewage, whereby the process of purification is ensured; and an important factor is the rate at which the particular sewage will take up the oxygen in the process, and also the amount.

TABLE V. *Points in Preliminary Methods.*

Preliminary Process.	Stay in Tanks*	Comparative Cost arranged in Order.†	Total Cost per Million Gallons (dry-weather flow).
		£	£ s. d.
Continuous flow settlement with Chemicals	8 hours	3,797	4 18 5
Continuous flow without Chemicals	15 hours	5,112	4 3 7
Quiescent settlement with Chemicals	2 hours	5,987	5 0 4
Quiescent settlement without Chemicals............	2 hours	5,987	4 1 7
Septic Tank....................	24 hours	6,891	4 7 2

* The above tanks would be sufficiently large to deal with 3,000,000 gallons per 24 hours in time of storm.

† These figures are approximate.

This Table has been drawn up from Tables prepared by the Engineer to the Fifth Royal Commission on Sewage Disposal.

Before deciding on the method to be followed in the settlement of the organic solids, their nature, and the rate of such settlement need to be taken into account. But little nuisance is caused in this process with domestic sewage, but this is not the case where brewery and tannery wastes are present, when the smell is most offensive.

CHAPTER XXI.

The Purification of Tank Effluents on Contact Beds.

Effluents from chemical precipitation and other sedimentation or septic tanks are further purified to fit them for final discharge from sewage works on what are known as "contact beds," or "percolating filters," filled with filtering media of various kinds. We shall deal here with "contact beds" on which the tank effluents are run and held up on the filtering media, which constitutes the purifying part of the beds, for a varying number of hours. This is known as the period of "contact" for oxidising the effluents; after which they are discharged, and the bed is then allowed to remain empty for a further period of time to aerate it, before being subjected to another "filling."

Filtering Media.

Various kinds of hard material are used for this purpose, because the oxidation and conversion into harmless salts of the offensive matters which they still contain is aimed at, and this, as is implied, necessitates a supply of oxygen from the atmosphere. Hence whether a contact bed or the later introduced percolating filter is employed, both are exposed to the outer air; the bed, or filter, being constructed of some coarse material as a medium, with the presence of air in the interstices, with a view to aiding the germs, and other low forms of life, which develop in the medium, in their purifying work. As a matter of fact, the greater the dilution of the sewage the better will be its purification under these conditions, owing to the fact that the oxidising bacteria present on the material and in the interstices require their supply of oxygen to be dissolved in water, as they cannot take it from the atmosphere direct.

With regard to the filtering material to be employed, its chemical composition is unimportant; preference is given to either coke, furnace clinkers, or what is known as "saggers" (vitrified stoneware, a waste material from pottery manufactories), now commonly employed in sewage works in the vicinity of the Potteries. The latter are hard, and do not disintegrate; are clean and free from any chemical matter; and there is an absence of dust. The surface of this material is also well suited to the bacterial colonies on the contact beds (and filters also). The saggers, or other medium, should be broken up to the required gradings, from $\frac{1}{8}$ in. up to $1\frac{1}{2}$ in. or 2 ins., or even larger. They are suited to both ordinary and "mixed" sewage.

With the latter, however, where "contact" is employed, primary and secondary contact beds should be used in succession upon which to run the effluent, if not a third bed. The primary bed ought to be composed of coarser material than the other two, with a view to eliminating any of the solids present that are still in the tank effluent prior to its passing on to the second or third bed.

The pieces of whatever material is employed should be hard and broken with a hammer to the required size; and before being placed in position should be put in water, preferably in some kind of small tank, to remove all kinds of dust and finer particles. It might be added that gravel, flints, broken granite, and broken Staffordshire bricks are also employed as filtering material for contact beds.

Size of Filtering Material.

More intimate contact of the tank effluent with the material, and consequent greater purification, as well as the more efficient arrest of the organic solids in suspension, is ensured by the greater internal surface area exposed to the tank effluent. Up to a certain point this would be ensured by the filtering material being of small diameter, but its efficiency depends also very largely upon the admission of air to all portions of the bed, whilst it is resting empty for aeration purposes. The material should, therefore, not be of too small a size.

Medium sized sand would possibly give the most satisfactory results with effluent from tanks containing little suspended matter.

CHAPTER XXII.

The Construction of Contact Beds.

Contact beds are constructed in a variety of ways, by simple excavation, or some kind of building material—brick, or concrete, or both. It is, however, considered desirable that these beds should, unless the circumstances are exceptional, be constructed of building materials; these must certainly be used for outlet chambers, even in the most impervious soils. Where the soil is dense clay or loam simple excavation may be sufficient.

Filling and Emptying Contact Beds.

No hard and fast rule, which can be of general application, can be laid down as regards this point. If the beds are filled three times daily, two hours of "contact" of the tank effluent on the beds are found to give the best results, whether it be from chemical precipitation, septicised, or other form of sedimentation. Four hours "resting" from the reception of a further quantity, to give the beds sufficient time for the purpose of aeration, are usually found necessary, subject to the dilution of the sewage and the age of the beds themselves. The period of contact is less important than time given up to "resting." It would seem, however, that a long period of contact ensures the breaking down of the organic solids in suspension in the tank liquor, and this is helped by its being discharged fairly evenly over the surface of the bed. At Calverley the beds have been filled less than once daily, and the period of contact varies from six to twenty-four hours.

To avoid the creation of a nuisance from smell in filling the beds, the supply channels should preferably be fixed a little space below the top of the filtering material. To ensure this more completely it has been suggested that the supply channels should be fixed at the bottom of the bed, and the incoming effluent forced upward.

Loss of Capacity.

The causes of loss of capacity have been summarised by the Fifth Royal Commission as follows :—

(1) Disintegration of the filtering material.
(2) Consolidation of the filtering material.
(3) Growth of organisms.
(4) The volume of liquid passed on the bed.
(5) Insufficient rest.
(6) Inefficient drainage.
(7) The amount of suspended matter in the liquid passed on to the bed.

Amount of Sewage Effluent which can be dealt with on Contact Beds.

This will vary in quantity with different classes of sewage, and will depend, also, on the degree of purification desired, on the size of the filtering material, the strength of the sewage, and on the amount of solids in suspension in the tank effluent.

Contact bed effluents are not so satisfactory, generally speaking, as those from good land properly worked, as the latter contain practically no solids in suspension. This, however, cannot be said of contact beds.

The Action of Contact Beds.

This has been set forth in the Fifth Report of the Royal Commission, issued in 1908, as follows:—

"Our knowledge of the action of a contact bed is very incomplete, and little is known as to the manner in which the organic substances of sewage are broken down during the first stages of fermentation into carbon dioxide, ammonia, etc. The purifying agents seem to be not only bacteria, but also worms, larvæ, insects, etc., and we can offer no opinion as to the respective amount of work done by each set of agents."

It probably differs to some extent according to the nature of the sewage. It has been observed that at some places large numbers of worms are present, while at others there are comparatively few. Little is known of the kind of bacteria essential for purification, or as to their mode of action during the period of rest, or aeration, after the filter is emptied. There are, however, grounds for thinking that the "resting" period is the more important of the cycle.

Diameter of Material.

This depends chiefly on the amount of the suspended solids which the sedimentation tank effluent contains when discharged on to the contact beds. Materials of three sizes are commonly used—coarse, medium, and fine, of diameters of 3 inches and upwards, $\frac{1}{2}$-inch to 1 inch, and $\frac{1}{4}$-inch diameters, respectively.

Here it may be mentioned that the media employed for percolating filters are generally the same, save that a very fine material of $\frac{1}{8}$-inch diameter is frequently used. But, according to the results arrived at by Mr. Stoddart, recently announced, the size "is far too small for tank effluents as generally met with, but will be quite practicable when the preliminary treatment has been perfected."

Rate of Filling Contact Beds.

With coarse material the rate of treatment should not exceed one to one-and-a-half fillings per day for double contact, at the rate of thirty to forty cubic yards per day. In every case the material on contact beds should be washed about once in every eighteen months or two years.

With medium material the rate of filling, if the tank liquor contains ten to fifteen parts of solids in suspension per 100,000, should be about two fillings per day (50 gallons per cubic yard of filtering material per day for single, or 100 gallons per cubic yard for double contact), but the material ought to be thoroughly washed, or renewed every three to five years.

With fine material, tank effluents treated thereon should not contain more than four or five parts of matters in suspension per 100,000.

Washing of Filtering Material.

Various methods are employed for this purpose. At Leeds the washing is performed by hand with screens and a heavy flow of water, at a cost of 2s. 5d. per cubic yard.

At Hampton, a machine, driven by compressed air, is used for the purpose; and the cost of removing the old material, screening, washing, and replacing it in the bed, and making up the deficiency of about 25 p.c. with new material is 1s. $9\frac{3}{4}$d. per cubic yard.

CHAPTER XXIII.

Some Contact Beds Described.

Whether the tank effluent results from chemical precipitation, sedimentation, quiescent, or septic tank treatment, it is by no means pure enough to warrant its discharge into any stream of water, unless the latter be very foul in character. Consequently, some method has to be adopted to "purify" it, as far as circumstances and requirements call for.

Where a sufficiently large area of land can be acquired, passing the effluent through this may be sufficient, but the price of land in a convenient situation is frequently prohibitive.

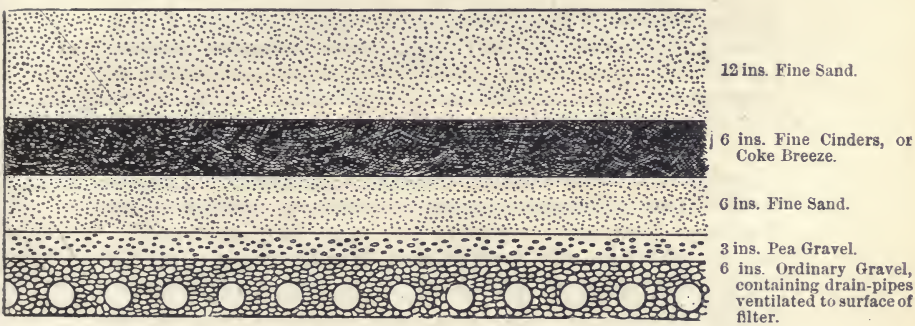

Fig. 14. Section of Early "Contact" Bed.

Specially constructed contact beds or filters are therefore most usually employed.

Fig. 14 illustrates section of one of the earliest kinds of contact beds. It is composed of layers of sand, gravel, fine cinders, or coke breeze. With a depth of 4 feet 6 inches of fluid upon the surface, this will successfully filter the sewage effluent at the rate of five hundred gallons per day per square yard of surface area.

It is essential that the beds have periods of "rest" in order to revivify them; the frequency and duration of these rests will depend upon the nature of the sewage effluent to be purified. The top surface of sand, to a depth of about half an inch, requires to be occasionally replaced. A very suitable area for a bed is a quarter of an acre. The effluent passes successively through the various layers in the bed, and is thus "purified." On reaching the pipes at the bottom of the filter, it passes away into some adjacent stream. Such a filter as this, with proper treatment, will continue for some years to produce a satisfactory effluent.

Lowcock's System of Filtration.

This, although on the same lines, was considered somewhat of an improvement. The bed is composed of some seven layers of sand and gravel, the top layer consisting of nine inches of sand, which only allows the sewage to pass very slowly through it, and at the same time arrests any matters that may remain in suspension after treatment in the settling tanks. Aeration is most essential to the working of the bed; therefore the fourth layer contains air-pipes, into which air is forced by means of a blower. The pipes are so fixed as to allow the air to pass through all parts of the filter bed. At the bottom of the filter are the usual effluent drains, through which the purified effluent passes away into a watercourse. A portion of the surface sand requires replacing at intervals.

Various Kinds of Contact Beds.

At Kingston-on-Thames, where the chemically-precipitated effluent is treated by single contact, the quality of the resulting "finished" effluent is described as "good." Results given by the contact bed of coke there, with six fillings (246 gallons per cubic yard per day), are also "fairly good."

The effluents from the coke beds are stated to have been, as a rule, slightly better than those from clinker beds.

At Andover there are eight contact beds, the size of each being, approximately, 44 feet by 25 feet, with an area of 122 square yards, a depth of material of 4 feet, and a cubic content of 163 cubic yards. They are constructed of brick and cement throughout, the filtering material being locomotive furnace clinker, broken to pass a half-inch screen. The septic tank effluent is distributed by six lines of 6-inch stoneware channels, laid on the top of the clinker, and fed by a main distributor, ranging from 9 to 6 inches in diameter. The effluent is collected at the bottom of the bed by two lines of 2-inch agricultural pipes, laid on the floor of the bed. These discharge into a stoneware main collector, from 4 to 9 inches in diameter, which runs into a cast-iron discharge well containing the discharge valve.

The beds are divided into two groups of four beds each, three in each group working at one time, whilst the two remaining are "resting" for purposes of aeration. The filling and emptying are effected by means of automatic gear in the following manner:—As soon as the bed is filled, a small quantity of filtered effluent flows from the discharge valve into its actuating bucket, the fall of which closes the admission valve to the bed, and, on its rising again after the proper interval has elapsed, it opens the discharge valve and releases the contents of the bed. The discharge of a full bed brings about the emptying of the actuating bucket in the next bed. The time required to fill a bed and the length of contact have varied considerably during the life of the beds, chiefly because of their loss of capacity; but on the average the fillings have taken about three-quarters of an hour, and the period of contact about an hour.

The general quality of the resulting finished effluent is described as "Poor."

(These contact beds are dealt with here, not on account of their value as producing a satisfactorily finished effluent, but to describe their general construction and method of employment.)

To enable contact beds to drain properly a few inches of large material is laid on the floor of the bed.

Depth of the Beds.

This varies very much. At Oldham the shallow contact beds are only 1 foot 6 inches deep, and the general quality of the effluent therefrom is described as "Moderate." At Maidstone it is 4 feet 4 inches, and the double contact is described as giving an effluent "Moderate to Fair." At Leeds the depth varies from 6 feet to 3 feet, and the resulting effluent is described as "Fair."

It would appear that contact beds should not be constructed of a greater depth than 6 feet, or of a less depth than 2 feet 6 inches, though within ordinary limits the depth makes practically no difference to its efficiency per cubic yard.

Comparative Cost of Treatment of Sewage by Land and on Contact Beds.

TABLE VI.

Land Treatment.

Class of Soil and Subsoil, and Method of Working.	* Cost per head of population draining to works. £ s. d.
Class i. Sub-class a. Filtration with cropping	0 0 8¾
Class i. Sub-class b. Filtration with little cropping	0 0 6¾
Class i. Sub-class c. Surface irrigation with cropping	0 0 10½
Class ii. Surface irrigation with cropping	0 1 3¼
Class iii. Surface irrigation with cropping	0 1 9

TABLE VII.

Contact Beds: Methods of Treatment.

Contact Beds.	*Cost per head of population draining to works. £ s. d.
Chemical precipitation, quiescent settlement, followed by single contact beds	0 1 4½
Chemical precipitation, continuous flow settlement, followed by double contact beds	0 1 6½
Quiescent settlement, followed by double contact beds	0 1 7
Continuous flow settlement, followed by double contact beds	0 1 9
Septic tanks, followed by double contact beds	0 1 9¼

*This is calculated on a population of 30,000, and on a flow of 33 gallons of sewage per head per day, and assuming that really suitable land can be purchased at £100 per acre. The relative cost must depend on a variety of circumstances, which will differ in almost every case.

CHAPTER XXIV.

Percolating Filters.

INTRODUCTORY.

With this class of filtration the tank effluent flowing on to the filtration beds passes down through them, and out by similar drains to contact beds, and does not remain in contact for any period, beyond the time of passage through the filter.

Percolating or trickling filters give a greater rate of filtration than contact beds. The rate of filtration in the case of the former may, generally speaking, be double, or nearly double, that of the latter.

Coarse material should be employed if the tank effluent contains much matter in suspension. Where the effluent is weak, fine material on shallow filters will generally suffice for satisfactory results.

Local conditions and the nature of the sewage, in conjunction with the above features, will determine the circumstances under which filters should be used.

Distributing Tank Effluents over Percolating Filters.

There may be considered to be five chief methods of effecting this:—

(1) A springler which moves, either automatically, or by applied power, dropping or spraying the liquid as it rotates or travels backwards and forwards over an area of filtering material (as Figs. 17-20).*

(2) A stationary form of distributor, in which the liquid to be distributed is carried over the filter area by means of pipes and forced under head of water through a large number of orifices, so that it is broken up into fine jets, and thus sprays the effluent over the media.

(3) A form of distribution in which definite volumes of liquid are automatically delivered in flushes.

(4) Dripping trays, a stationary form of distributor invented by Mr. F. Wallis Stoddart, by which the

* See pp. 89-92.

sewage liquid is carried over the filtering area in perforated trays of corrugated iron, from which it falls upon the filtering material in a succession of drips (Figs. 15-16a).*

(5) Tipping troughs, a stationary form of distributor, consisting of troughs balanced on pivots in such a way that, when filled, they tip and discharge the sewage on to the filter bed, and then return to their original position (Figs. 21-22a).† This method is, generally speaking, more suited to small and private installations.

Construction of Filter Base.

If the materials employed are coarse in character, large quantities of the solids in suspension in the tank liquor will make their way through and pass away with the "finished" effluent. In this way aeration is practically prevented, owing to choking of the bottom layers in the material which arrests some of this suspended matter.

From time to time the upper part of the filter material should be washed or riddled, to remove the matters in suspension therefrom.

The layers of material in the lower portions should be such as to permit free passage of air through the bed.

The filters themselves need little attention, the uppermost layers requiring only occasional raking; the lower ones are not touched.

Some Filters and Apparatus Described.‡

Stoddart's Continuous Filter.

At Horfield (Bristol) Stoddart's Continuous Sewage Filter is used (Fig. 15). For his system the inventor claims that it satisfies the following requirements:—

(1) Utilisation of the whole available "fall."

(2) Instantaneous adaptability, without adjustment, to all rates of flow, however varied.

(3) Treatment of sewage and storm-water on the same area.

(4) Total absence of moving parts.

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* See pp. 83, 84 and 86. † See pp. 128-131.

‡ In outlining some of the features of one or two varieties of filtering apparatus, it is by no means the intention of the writer to infer that other kinds do not possess valuable features.

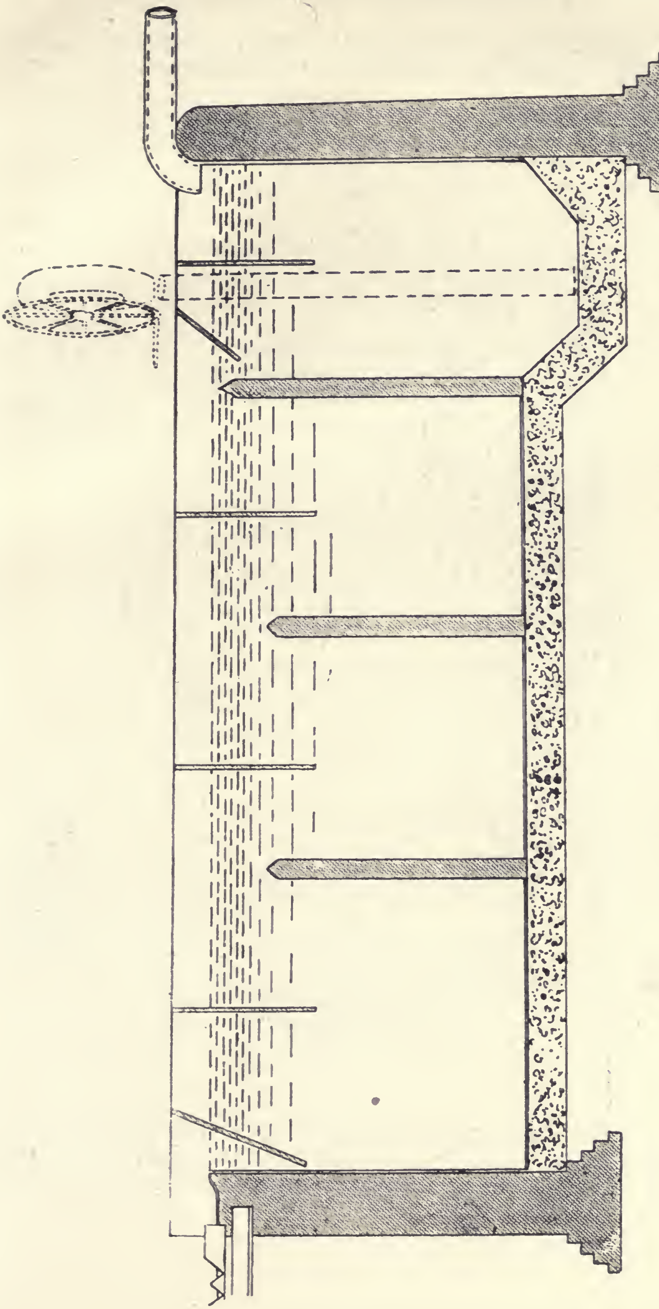


Fig. 15. Longitudinal Section of Stoddart's Continuous Filter.

This filter can, if desired, be entirely closed, so that the sewage is never in a position to diffuse odour.

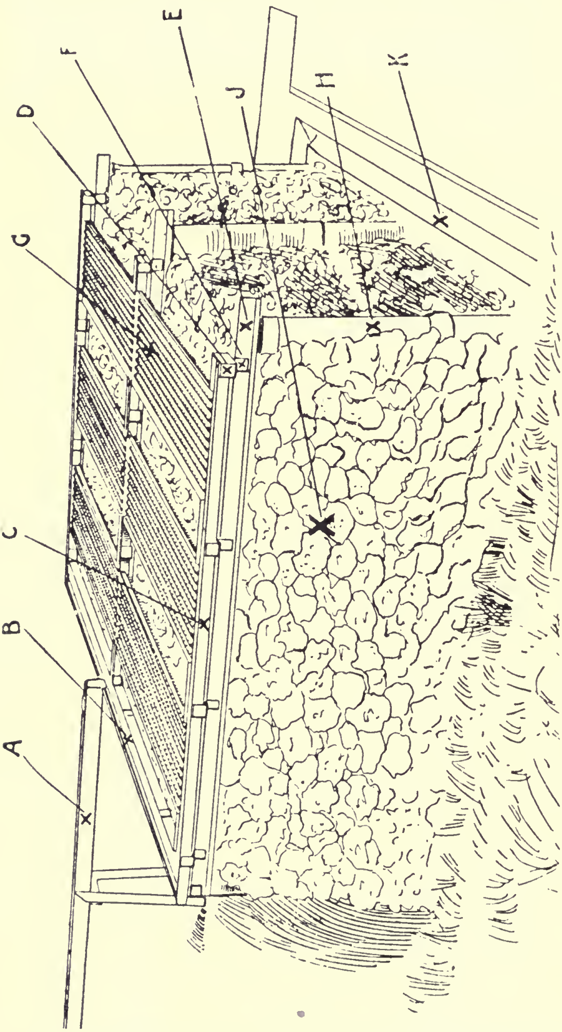


Fig. 16. Key to parts of the Stoddart Sewage Filter.

A—Feed Channel from Tank.
B—Main Channel.
C—Supply Channel.
D—Stopend or Penstock.
E—Iron Tee.
F—Chair with Set Screw.
G—Distributor.
H—Pier.
J—Filter Body (clinker).
K—Collecting Channel.

At Horfield, gas works clinker, graded as nearly as possible to 3 inches in diameter, and a depth of 7 feet 5 inches of filtering material, is used. The grading of this material is done by means of washing and riddling, the broken pieces being thrown into water, and then lifted out again with a wide pronged fork.

This method is put forward by Mr. Stoddart as being greatly preferable to the ordinary riddling, in that it removes all the fine clinker adhering to the larger lumps.

At Knowle (Bristol) another of Stoddart's patent distributors is used. It deals with a septic tank liquor, with efficient results in many ways, though by no means perfectly. The trays there are well sheltered. In many respects, however, the conditions are not considered ideal for a fair test of the apparatus.

The resulting effluents are of a high class, bacteriologically and chemically, apart from the organic solids in suspension.

The Stoddart distributor (Fig. 16A) consists of a gutter provided along the bottom on the under-side with a series of drip-points. On filling with liquid, the latter overflows the margins of the gutter, and on reaching the nearest drip-point falls upon the surface of the filter in a succession of drops.

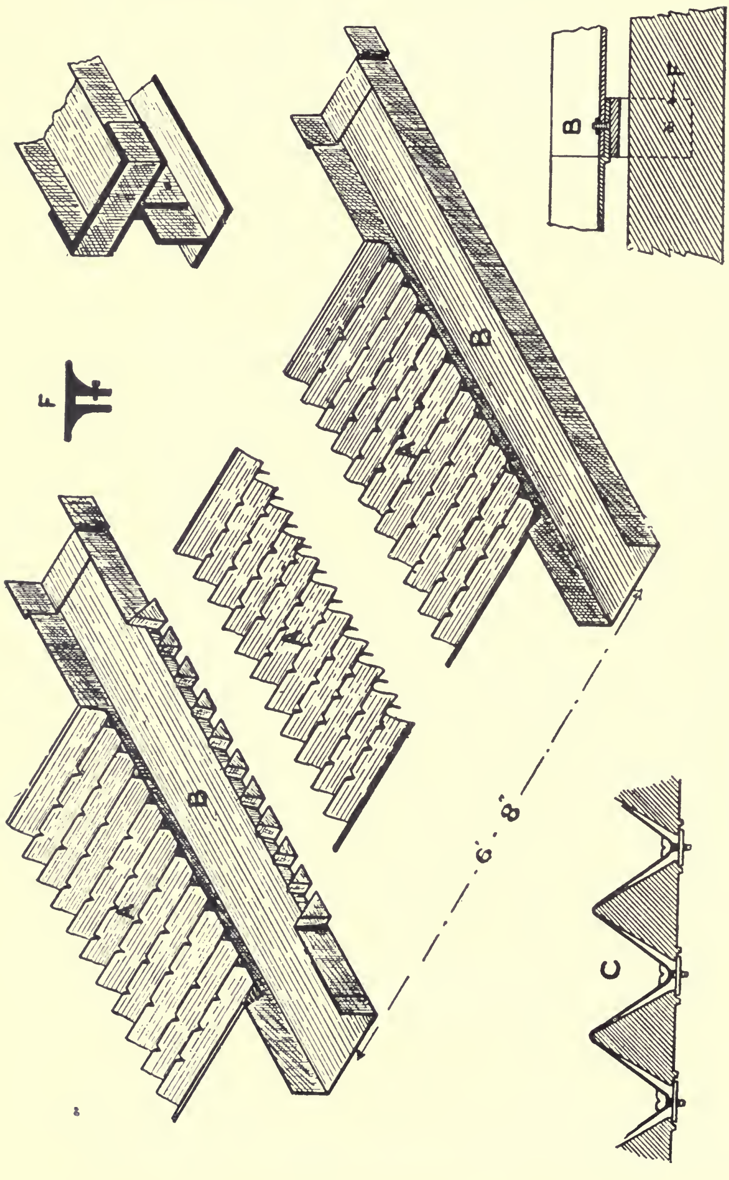
The gutter is made V-shaped in section, partly to secure the maximum of rigidity, partly to direct the liquid towards the drip-points. Several distributor gutters are conveniently united together to form a distributor sheet, provision being made for the passage of the liquid from the upper to the under surface by a number of openings between the gutter.

These openings may be of any size, as they do not determine the comminution of the liquid, this being effected by the drip-points.

The distributors are connected with the sewage tank by means of specially-designed cast-iron channels (supply channels), provided with recesses to form water-tight joints with the end of the distributor, and the whole apparatus is supported by adjustable chairs carried on iron tees, by which means levelling is readily effected.

When the system of channels and distributors is in action, the liquid should stand at one uniform depth throughout, whatever quantity of liquid is being applied, and the exit, it is claimed, is so free and unimpeded that it is immediately disposed of.

Hence, as it is considered, the distribution is completely independent of variations in the rate of flow, the only difference observable being in the rapidity of the dropping. Moreover, as the comminution of the liquid is effected in the



THE STODDART SEWAGE DISTRIBUTOR (PATENT).

A, Distributor *B*, Supply Channel. *C*, Attachment of *A* to *B*. *F*, Chair with Set Screw.

Fig. 16A. Effluent Supply Channels to the Stoddart Sewage Filter.

interval between the margins of the distributor gutters and the drip-points below (scarcely more than one inch), practically the whole of the fall is utilised in the filter body.

The members of the Fifth Royal Commission report that :—"In ordinary cold weather and frost the working of the Stoddart filter is not affected, except in so far as there is a slight lowering in the temperature of the effluent. The distribution at Horfield has been uniformly efficient during our observation, though not perfect."

Aerating Trays.

At Caterham Barracks, the depôt of the Foot Guards, there are four "Aerating Trays," as the filters are called, each 11 feet by 9 feet 6 inches, an area of 23¼ square yards, a total area of 93 square yards, and a 5-feet depth of material (coke). The sewage is an exceptionally strong domestic one from some 1,300 men, and is first treated by septic tank, and what is called by Mr. Scott-Moncrieff, its inventor, a "Cultivation Tank," 42 feet by 20 feet, by about 8 feet in depth, in which the filtering material is flint.

The effluent from a closed septic tank is received into the cultivation tank by means of a large perforated pipe from the primary tank, and enters the cultivation tank underneath the flints, and is discharged from it in a highly-septicised condition through three outlets near its surface.

The aerating trays are arranged in the form of four filters, each consisting of seven concrete trays, perforated at the bottom and filled with coke. The coke is graded from three-eighths of an inch in diameter in the uppermost tray to about three inches diameter in the lower ones.

The distribution of tank liquor is effected by the tipping of four troughs, which each discharge about fifteen gallons of liquid into perforated pipes extending over the surface of the material.

At the ordinary rate of flow the discharges take place about once in twenty minutes. If the distributing pipes are kept clean, the method is very effective; but they need constant attention, and require to be brushed and picked out at least twice a week when the flow is at the normal rate.

The total time which is spent in cleaning the primary tank and the pipes each week is about twelve or fourteen hours for one man. During this time the filters are out of work, and the whole of the tank liquor goes to the land.

The filters themselves need little attention, the uppermost trays requiring only occasional raking; the lower ones are not touched.

Some Rotating Distributors Described.

Fig. 17 illustrates a Scott-Moncrieff Rotating Distributor on a quarter-acre bed, similar to those in use at the works of the Birmingham, Tame, and Rea District Drainage Board. The apparatus shown is driven by its own oil motor, which renders it quite independent of the "head" or volume of the sewage effluent. The bed has a vertical stand-pipe in the centre, into which the effluent from the tank flows; a horizontal arm attached thereto is capable of being revolved about the centre. Fig. 17a will help to explain this. The revolving arm consists of a large main trough or carrier, into which the sewage is delivered from the vertical stand-pipe just alluded to. This arm is quite close to the surface of the filter-bed, thus preventing any sewage spray from being blown about by the wind.

The distributor is so constructed that the same amount of sewage can be discharged in a given time over each square yard of the filter-bed, and by this means no portion of the bed is under- or over-worked; thus the rate of discharge (that is to say, the daily amount of effluent poured on to the bed) can be regulated. Intermittent aeration is also provided for. By whatever system sewage is treated, if it requires subsequent filtration through "beds," this distributor can be employed, and it can be constructed to suit any shaped filter.

At Accrington, fourteen filters are in use to deal with the septicised sewage of some 46,300 persons—in open tanks. The majority of the population is served by water-closets constructed on what is called the "Waste water system," in which the closets are flushed with slop water, and in wet weather also by water from the back roofs of the houses.

A considerable portion of the population is still served by the pail system, there being something like 2,000 pails, and as the contents of these are tipped into a tank at the depôt, which is flushed into the sewers twice a day, they may be looked upon as having much the same effect on the sewage as water-closets.

These are all circular "trickling" filter-beds, having a diameter of 49 feet 9 inches, a depth of 8 feet, and a cubic content of 588 cubic yards. The filtering material is either coke, ranging from 2 inches to 4 inches in diameter, or clinker of the same diameter.

The distributors are propelled by either automatic action or steam.

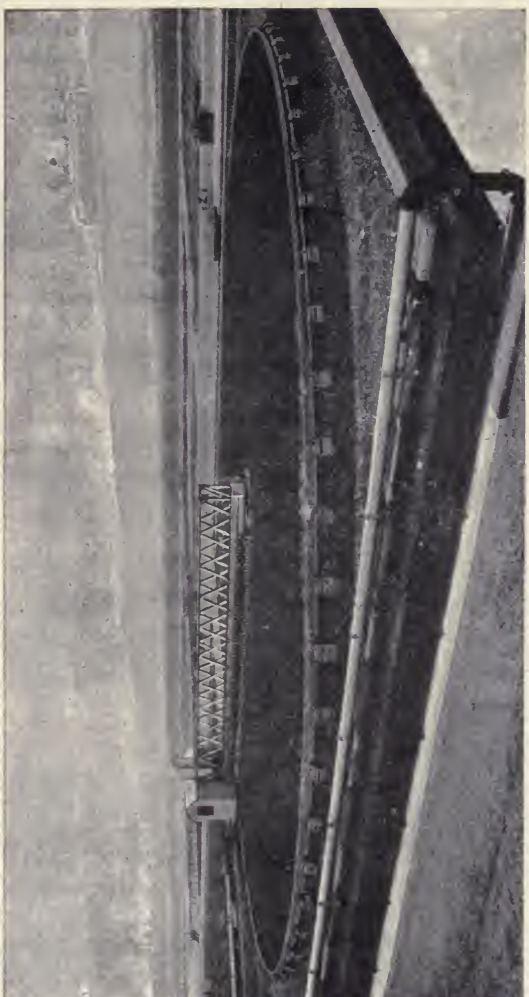


Fig. 17. Scott-Moncrieff's Effluent Distributor.

The construction of the filters is simple, the material being built up on a false bottom, consisting of large semi-circular

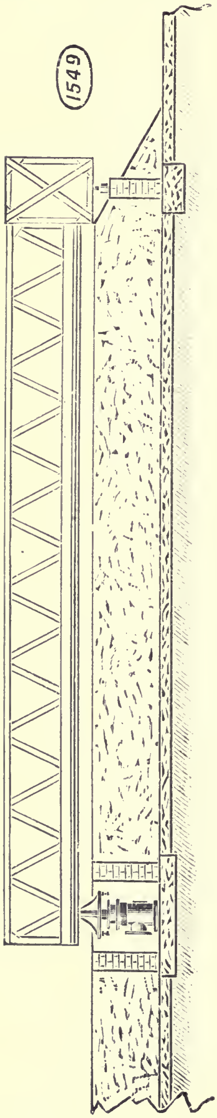


Fig. 17A. Revolving Horizontal Arm to Scott-Moncrieff's Effluent Distributor

perforated pipes, which rest on a concrete floor, and are kept in position by a wall of pigeon-hole brickwork constructed in the form of an octagon. This is carried up to a height of some 7 or 8 feet above the concrete floor, the material from that point to the surface of the bed being given a slight batter towards the centre.

The distribution of the septicised open tank liquor is effected by three kinds of distributors; the finished effluent from each kind being about the same in character. All the effluents are well nitrated, are of a brownish tint, contain an unusually large quantity of flocculent solids in suspension, and need to have them removed before being discharged into any watercourse. A satisfactory feature, however, is the fact that finished effluents may be exposed to the air for as long a period as five days without undergoing any appreciable change.

Farrer's Rotary Distributor.

The "Facile" Automatic Continuous Rotary Distributor possesses certain features of its own, including adjustable drop pipes, which allow for variation of levels (in cases where several "beds" are worked from one "feed"). Fig. 18 illustrates a filter apparatus of this class at work at the Bradford (Yorks) sewage works.

The Fiddian Distributor.

This distributor is constructed so as to be readily adjusted to variations in flow. It consists of an elongated waterwheel (usually) 18 inches diameter, so constructed as to revolve on its horizontal axis, and automatically to travel over the surface of a filter,

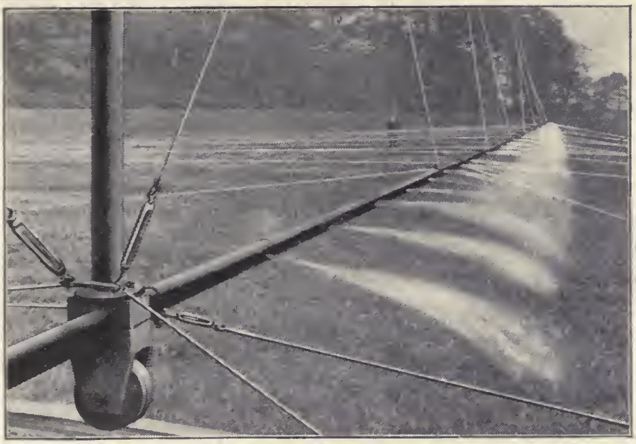


Fig 18. Farrer's Automatic Distributor.

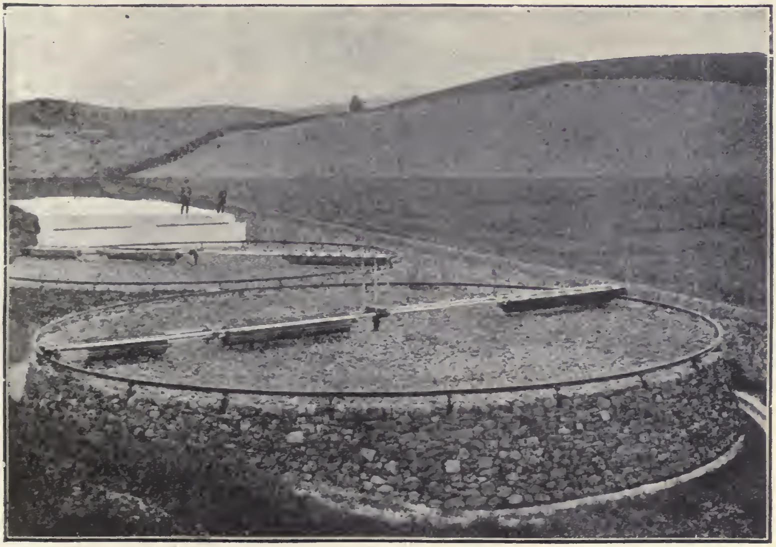


Fig. 19. Triple-drum Sprinkler on Circular Filter.

by means of wheels fixed on, or connected to its axle. The sewage is fed with the tank effluent by a supply pipe, and from this the sewage falls into the buckets of the wheel, and then spreads itself along the bucket, and by its weight causing rotation of the wheel-drum. The sewage is sprinkled from the buckets while the Distributor is revolving. A "head," or fall of some 15 inches, is sufficient to actuate the apparatus.

Fig. 19 illustrates a Triple-Drum Rotary Distributor for circular filters, as in use at Leslie.

Travelling Distributors.

This class of distributor, or sprinkler, is not so frequently used as those of the revolving type.

Fig. 20 illustrates Single-drum Travelling and Reciprocating Distributors on the Fiddian principle (see Fig. 19), at

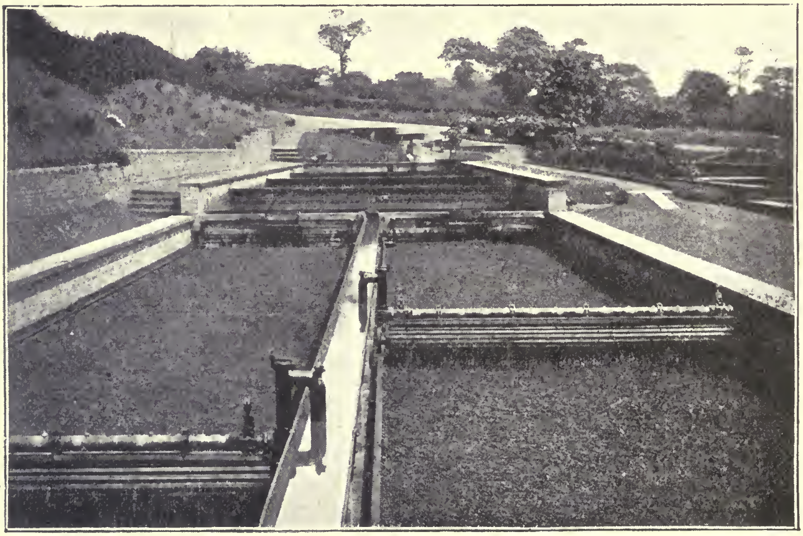


Fig. 20. Single-drum Travelling Distributor.

the installation of the Heaton Norris Urban District Council, employed on rectangular filters each 92 feet long, 14 feet wide, and 3 feet deep, distributing at an average rate of 500 gallons per square yard per day strong chemically precipitated sewage, the effluent passing direct to the river Mersey. The effluent from the tank is drawn from the trough (shown in illustration) by means of the syphon, and flows along the feed tube and thence into the buckets. The apparatus is arranged to ensure a reversal when the distributor reaches the end of the filter, and the return is forthwith commenced. A working "head" of some 27 inches actuates this Distributor.

Some Facts as to Cost of Maintaining Distributors.

The problem as to what expense is justified, especially in large schemes, in maintaining highly efficient distributors, as against less efficient ones involving less expenditure in first cost and perhaps in maintenance, is important, and has recently been discussed by the Institution of Civil Engineers in connection with Mr. Watson's paper on the Birmingham Outfall Works. There filters 6 feet deep and fixed spray jets give a purification of from 33 per cent. to 64 per cent., treating 85 gallons per cubic yard per 24 hours. The total cost of the distributing apparatus, however, was only 6 per cent. of the total cost of the filters, and the tests for uniform distribution gave very poor results. The filtering medium is often very costly, but the work it is capable of doing depends largely upon the distributor, and this should be capable of sprinkling any varying quantity from a rate of about 100 gallons per square yard per day to 500, with a variation from the mean not exceeding 25 per cent., the unit area of measurement being 25 square yards (18 inches by 18 inches). Mr. Watson made some valuable experiments through a raised filter, showing that as the liquid was sprinkled on the surface so it passed through and emerged from the bottom, thus disposing of the popular error that the liquid tends to spread itself out as it passes down.

CHAPTER XXV.

Growths on Contact Beds and Filters.

These growths appear to be of various kinds, and are but little understood. At many works they are the cause of putrefaction, even if they do not prevent the proper conduct of the method of treatment. These growths vary in appearance and in the length of time they take to grow. Variations in colour are also features of these growths. It does not seem that the method employed in the settlement of the solids has anything to do with it.

According to present knowledge, it would appear that from tank effluent, passed over filters, growths take place with most kinds of sewage; whether the crude sewage has been precipitated by chemical or by septic action, and where the filtering medium is clinker. With precipitated effluent, at Dorking, for instance, a pinkish-yellow, filamentous growth appeared a fortnight after the filters were brought into use.

This lasted six months, and then died, having caused the effluent to be bad during that period. On the other hand, at the same installation, with the same kind of sewage, where septic effluent was dealt with, the growth, which lasted for a similar period, did not become so strong nor cause interruption in the process. The growth is described as a grey-brown amorphous one.

At Kingston-on-Thames, the grey growth is an annual one, from November to March. The effluent becomes bad during wintry weather because the growth forms an almost impervious mat on the surface of the filtering material.

With regard to the use of media which cause least trouble from growths, it makes but little difference whether the medium is clinker, broken brick, granite, saggars (vitrified stoneware), or sand.

In some cases with sand, as at Chorley, the filters being washed every week, after eight years' use there was still an absence of growth. At Horfield, with coarse clinker, and at York, with broken brick, coke, and slag, the result was similar after four years. On the other hand, at Accrington, clinker beds showed slight signs of growths, but only on their surfaces; whilst at Birmingham, with broken brick or granite, similar signs were visible at the end of a year. Little is known as to the nature of these growths, and experiments are being conducted, to ascertain as far as possible the nature of them. It would seem, however, that filters having surfaces of fine material are not so much affected. The gelatinous growths can be, to a large extent, killed with either of the following agents or re-agents: 20 per cent. solution of "chloros," copper sulphate, ferrous sulphur, caustic soda, sulphuric acid, bleaching powder, or powdered quicklime.

Growths at Outfalls and in Streams.

In the ordinary way, River Boards permit all effluents, which are non-putrefactive, to enter the streams under their control without further treatment.

Under present circumstances of treatment, even the best-finished effluents cannot be looked upon as free from the possibility of causing objectionable growths in the streams in which they are discharged; and especially is this the case in the vicinity of the outfall, where the effluent may decompose and cause a nuisance.

Some effluents permit of growths which, on decomposition, and especially in masses, give rise to considerable nuisance.

Water weeds will also grow at outfalls, in such a manner as to cause much trouble at times, which necessitates their removal. A few grains of chloride of lime will arrest such growths.

The first portion of the effluent from contact beds is not quite as thoroughly oxidised as the last, and effluents from these beds are almost completely de-aerated; but in all probability it would not be a difficult matter to aerate such an effluent prior to its discharge into a stream. This may possibly be, to some extent, the cause of objectionable growths taking place, at the outlets of contact beds; where the "finished" effluents are discharged. Fine material should be used for the top six inches of contact beds, so as to arrest some of the suspended solids, and to enable them to be removed with it, and at the same time to prevent the choking of the beds. For the like reason, the filtering material, over the drains, at the bottom of the beds, should be of fairly large size. Attention to these details will also preserve the life of the beds.

In order to lessen the rate of loss of capacity in contact beds, certain points have to be observed. These include:—

Giving the beds proper "rests" at suitable intervals;

Using material which does not disintegrate;

Preventing as far as possible suspended solids from entering the beds;

Giving efficient drainage; and

Taking care not to overwork the beds.

Unless this is done the beds will quickly lose a large amount of their oxidising powers.

The rate of loss of capacity varies with the quantity of matters in suspension reaching the beds, with the nature of the sewage, and with the rate of filtration.

This loss will be rapid at first, and, thereafter, at a much less rate.

If too fine a material is employed, the rate of filtration will be very slow.

Choking of Beds.

To prevent this the material should be sufficiently coarse. Not only does this ensure free and satisfactory working; but this precaution also obviates forking the surface of the beds, which is too frequently rendered necessary by internal clogging.

At Accrington, where coarse material has been employed in dealing with septicised effluent, no clogging has resulted from eight years' work.

As is noticed elsewhere, the material has to be washed, to prevent growths on its surface, and it is then riddled or sieved dry.

In some cases, where fine material is employed, even though only a small quantity of tank effluent is dealt with, not exceeding 25 gallons per cubic yard per day, the surface of the filter has become entirely choked within a month.

Table VIII. shows the state of various kinds of filters, at different works, depending, to some extent, on the nature and size of the filtering materials, and on the amount of the suspended solids in the tank liquor.

TABLE VIII. *Comparison in Media, etc., and Clogging of Filters.**

Place.	Nature of Material.	Size of Material.	Amount of suspended matter in tank liquor treated. Parts per 100,000.	Rate of Filtration in Gallons.		Condition of Filters.
				Per Square Yard per 24 hours.	Per Cube Yard Per 24 hours.	
Leeds	Clinker	$\frac{3}{8}$ in. to $\frac{5}{8}$ in	80	83	25	Clogged after 1 month.
Market Drayton	Granite	$\frac{3}{8}$ " " $\frac{3}{4}$ "	25	50	20	Upper part of material required washing after about 4 years' work.
Hendon	Clinker	$\frac{1}{2}$ " " $\frac{3}{4}$ "	20	125	40	Good after 8 years.
Leeds	"	$\frac{3}{8}$ " " $\frac{5}{8}$ "	18	200	57	Bed seriously clogged after $2\frac{1}{2}$ years.
Chesterfield	"	$\frac{1}{4}$ " " 2 "	12	90†	40†	Good after 6 years.
Birmingham ...	Broken Brick and Granite	$\frac{1}{2}$ " " 3 "	8	125	70	Good after 3 or 4 years.
Hanley	Saggars	$\frac{1}{4}$ " " $\frac{1}{2}$ "	5	206	124	Upper part of material would probably require washing every 4 or 5 years.
Salford	Clinker	$\frac{3}{16}$ " " $\frac{3}{4}$ "	3	318	151	Good after years. Top foot of material renewed on 10 per cent. of area after 3 or 4 years, and rest of area dug over.

* From the Fifth Report of the Fifth Royal Commission on Sewage Disposal.
† Dry Weather Flow.

CHAPTER XXVI.

Ponding Effluents from Contact Beds and Filters.

It has recently been suggested, following beneficial results at the Berlin sewage farms, that effluents should be held up in ponds, to which fresh water may also be admitted, and in which such a high standard of purity might be attained as to enable coarse fish to be kept therein.

Well aerated and scientifically managed ponds are used on these lines at the Lichfield Sewage Works, with the result that the bed of the stream into which the effluent is discharged does not need clearing out nearly so often as formerly.

Similar ponds, constructed by utilising the excavations, made for obtaining the clay for burnt ballast used as the filtering medium for the contact beds, at the Worcester Park Sewerage Works of the Epsom (Surrey) Rural District Council, produce a very finely finished effluent.

Cost of Washing and Renewing Filtering Media.

(A) Contact Beds.

Approximately, where two beds are employed for the treatment of various classes of tank effluent, the cost per cubic yard, where machinery is employed, but excluding the prime cost of the plant, is an average of about 1s. 6½d. for removing, washing, and making good the material, reckoning the prime cost of the latter at 1s. 7d. per cubic yard. It is calculated that this process would be rendered necessary every four years in the case of primary, and every ten years in the case of secondary beds.

(B) Percolating Filters.

The cost in this case may, apparently, be taken as almost negligible, if care is taken to remove the first few inches at the top of the beds, to prevent them becoming clogged by the settlement thereon of any of the suspended solids in the tank effluents. For instance, it was found in one case that, after five years' regular use, a clinker bed was as good as when constructed. In another case, coke and clinker were still in use after constant wear for eight years.

Contact Beds and Trickling Filters Compared as Regards Efficiency.

Efficiency will vary, in almost every installation, owing to the fact that sewages differ in the extent to which they are diluted, and in the extent to which various kinds of organic solids are present in suspension. There seems no cause to doubt that filters are less affected by variations in flow than contact beds; nor can it be doubted that their effluents are better aerated, and, apart from solids in suspension, are more uniform in character. This, however, will necessarily depend upon the efficiency of the apparatus employed in feeding the filter. On the other hand, filters cause greater nuisance from smells, and also, in the warmer months of the year they seem to become the breeding-ground of a small midge-like fly, which is very annoying to workers.

Contact Beds and Percolating Filters.

Area and Cost of Land Required Compared.

In considering this point, it must be borne in mind that the cases given are largely hypothetical, as circumstances vary in almost every instance, and much depends on whether concrete is or is not used for the flooring of the beds. At Burnley, without concrete, their cost was £1,300 per acre, the beds being 3 feet deep. At Manchester, with the same depth, with concrete and no rendering, £2,500 to £3,000.

The figures in Table IX. were prepared by Mr. Kershaw, the Engineer to the Fifth Royal Commission.

The Table gives the area and the assumed cost of the land occupied by the installations.

The price of land throughout has been taken at £100 per acre.

Table IX.

Preliminary Process.	Contact Beds.				Percolating Filters.			
	Land required in Acres.	Cost of Land.			Land required in Acres.	Cost of Land.		
		£	s.	d.		£	s.	d.
Quiescent settlement with chemicals	1·26	126	0	0	0·73	73	0	0
Continuous flow settlement with chemicals	2·03	203	0	0	0·91	91	0	0
Quiescent settlement without chemicals	3·21	321	0	0	1·095	109	10	0
Continuous flow settlement without chemicals	4·18	418	0	0	1·46	146	0	0
Septic Tanks	4·18	418	0	0	1·46	146	0	0

CHAPTER XXVII.

Comparative Cost of Treatment by Land and by Artificial Processes.

In explanation of these particulars and Tables, which have both been specially prepared by the writer, the following remarks are given:—The "cost" is the annual cost per head of the population draining to the works, based on a daily flow of 33 gallons per head.

As regards the artificial methods of treatment, the same five preliminary processes are employed prior to the effluent being dealt with, on percolating filters in the one case, and contact beds in the other. These five are:—

(a) Chemical precipitation, quiescent settlement;

(b) Ditto precipitation, continuous flow settlement;

(c) Continuous flow settlement without chemicals;

(d) Quiescent settlement;

(e) Septic tank.

With land treatment, land possessing "all kinds of good soil and subsoil, e.g., sandy loam overlying gravel and sand," was, at different sewage farms, employed in three different ways:—(f) filtration with cropping; (g) filtration with little cropping; (h) surface irrigation. Both (i) heavy soil overlying clay subsoil, and (j) stiff clayey soil overlying dense clay, were used for surface irrigation with cropping.

Table X.

Comparative Cost of Treatment by Land and by Artificial Processes.

Percolating Filters.	s.	d.	Contact Beds.	s.	d.	Land Treatment.	s.	d.
(a)	1	2½	(Single Contact)	1	4½	(f)	0	8¾
(b)	1	2¼	(Double ,,)	1	6½	(g)	0	6¾
(c)	0	11¾	,, ,,	1	7	(h)	0	10½
(d)	1	0	,, ,,	1	9	(i)	1	3¼
(e)	1	0½	,, ,,	1	9¼	(j)	1	9

The cost of land treatment is the nett cost obtained, by deducting the returns from sale of crops, from the gross cost of treatment.

The figures in the Report, dealing with comparisons in cost of treatment, have, to some extent, been based on assumptions. The relative cost of different methods would, in practice, largely depend on local circumstances. "The differences in cost are, however, small." Local considerations must always play an important part in the selection of a method of sewage treatment: these circumstances will also control the degree of purification to be aimed at. One hundred pounds per acre should be the maximum price for a site for land treatment to which the sewage can gravitate. Where, however, "It was necessary to obtain a high-class effluent, it might be cheaper to pay a somewhat higher price for good land, rather than adopt artificial treatment," in which "effluents are generally distinctly inferior to those obtained by the treatment of sewage on land."

TABLE XI.

Total Cost of Complete Treatment.

CONTACT BEDS.

Preliminary Process.	Total Cost of Preliminary Treatment.	Total Cost of Filtration Process.	Total Cost of Complete Treatment.
	£ s. d.	£ s. d.	£ s. d.
Quiescent settlement with chemicals	3 8 11	2 3 11	5 12 10
Continuous flow settlement with chemicals...............	3 2 2	3 4 7	6 6 9
Quiescent flow settlement without chemicals	1 19 8	4 11 8	6 11 4
Continuous flow settlement without chemicals	1 10 11	5 11 4	7 2 3
Septic tank	1 14 6	5 11 4	7 5 10

TABLE XII.

Total Cost of Complete Treatment.

PERCOLATING FILTERS.

Preliminary Process.	Total Cost of Preliminary Treatment.	Total Cost of Filtration Process.	Total Cost of Complete Treatment.
	£ s. d.	£ s. d.	£ s. d.
Quiescent settlement with chemicals	3 8 11	1 11 5	5 0 4
Continuous flow settlement with chemicals	3 2 2	1 16 3	4 18 5
Quiescent flow settlement without chemicals	1 19 8	2 1 11	4 1 7
Continuous flow settlement without chemicals	1 10 11	2 12 8	4 3 7
Septic tanks	1 14 6	2 12 8	4 7 2

Explanation of Tables XI. and XII.

These figures are those of the Fifth Royal Commission; they are merely approximate, and are based on a dry-weather flow of one million gallons of sewage.

As regards contact beds, it follows that, where they are built by simple excavation and banking, the cost would be comparatively low. For the purpose of these tables the cost of double contact beds per acre is worked out at £5,700, including concrete, rendering, drains, distributing channels, engineering, and contingencies, etc. The beds are supplied with filtering material at a cost of six shillings per cubic yard, to a depth of three feet, and it is placed in position in the beds. At this rate it works out at about £1,396 per acre.

On the basis on which the figures have been worked out, it would appear that the purification of sewage effluents from the tanks can be effected by percolating filters at a cost of two-thirds that of purification by double contact beds

CHAPTER XXVIII.

Discharge into Estuaries and the Sea.

Most towns and smaller communities bordering on estuaries and the seaside are peculiarly well situated for efficiently disposing of their sewage. There are some exceptions to this, as we shall notice later.

Choice of Outfall.

The chief item to consider in this connection is the ques-of sea currents, which may be favourable or very unfavourable, and may either cause the return of the sewage to the shores from which it is discharged, or may cause it to be cast on those of the neighbourhood.

In either of these cases, the crude sewage must be treated by one of the methods previously described; and in cases where there is a resulting effluent, steps must be taken to ensure that similar precautions are taken in its discharge as indicated above.

The following is the most useful method of ascertaining a suitable spot for the outfall. As remarked above, returning tides and sweeping currents have to be taken into consideration.

"Floats," placed in the sea from the shore at the most likely spots, are used for the purpose, by means of which the action of the winds, tides, and currents may be carefully observed, with a view to discharging the sewage into the sea, at a particular time after the turn of the tide, so that the outgoing water may carry it out to sea with great velocity. The exercise of care, coupled with experience, is essential for this, because the proper choice of outfall is the chief element of satisfactory disposal of sewage. The floats are used in conjunction with specially-prepared charts. These floats, when placed in the sea, have to be carefully followed and watched, and the directions taken by them duly noted on the charts. That position on shore at which the floats were placed in the water, and from which they were carried out to sea in the most desirable direction, is the spot that should be fixed upon for the outfall. Part of these experiments should also be directed to ascertain the most suitable time at which the discharge of the sewage should take place after the turn of the tide.

To await the hour of discharge, the crude water-borne sewage matter has to be collected in tanks, their size varying with the quantity to be stored therein. These tanks are used for storage purposes only, for the reception and retention of the sewage as it enters them from the sewers of the district served, between one period of discharge and the next. It may be necessary, where the physical features of the district draining to the outfall require it, to "lift" the sewage by means of pumping machinery, actuated by some sort of power, into the tanks to enable its proper discharge from the outfall into the sea or other water.

Typical Outfall into the Sea (Portsmouth).

Owing to the fact that practically the whole of Portsmouth lies very low, the sewage has to be pumped at the outfall. Machinery is used to do this. In ordinary weather the sewage is lifted by pumping machinery actuated by steam; and when the weather is stormy, this is supplemented by the use of large gas engines. To effect the discharge into the sea, the sewage has to be lifted some thirty feet. Its discharge takes place one hour after high water, and one and a-half hours are allowed for the purpose.

The sewage has to be collected between the periods of discharge in tanks adjacent to the outfall. One, built of concrete and brick, has a capacity of four and a-half million gallons; another, built in ferro-concrete in excavation, has a capacity of six and three-quarters million gallons. The Borough Surveyor informs the writer that no nuisance is caused to the Portsmouth or adjacent shores; and that no growths are caused at the outfall or in the sea. It is necessary, perhaps, to add that at the hour of discharge the sewage is released from each tank by the use of penstock. (Fig. 47. p. 192.)

The Protection of Edible Shell Fish Layings.

Sometimes the cultivation of edible shell fish may constitute a staple local industry, or that of some adjacent community, and, therefore, beds of oysters, mussels, cockles, etc., may be laid down on the shores. Apart from the fact that the discharge of crude or imperfectly purified effluent is a controversion of Section 20 of the Rivers Pollution Prevention Act, 1876, and consequently is actionable, the owners of the layings have a right of action at common law on account of the injury to their industry which takes place. The latter is not infrequently caused either by the discharge of the sewage in the vicinity of the beds, or in such a situation that the sea currents will carry it thereto.

Where these conditions prevail, periodical examination of the water should be made, as the sewage may contain the specific organisms of water-borne disease, some of which, as the typhoid bacillus, the causation of typhoid, or enteric fever, are most virulent in their character. The latter microscopic germs have been the cause on many occasions of the outbreak of severe cases through the consumption of contaminated shell fish.

The importance of protecting these layings is recognised, and need not be further emphasised.

We shall notice that legislative action is contemplated, with a view to ensure the protection of edible shell fish layings. In the meantime, it should be incumbent on all local authorities, whose districts are situate in their vicinity, to ensure that every care is exercised in the choice of an outfall. In connection with this latter, it is necessary to bear in mind that in the case of effluents, if they are imperfectly purified, they may be the means of carrying disease germs; and this may even be so with effluents of the highest standards. Whether the liquor in question is from septicised or chemically-treated sewage makes no practical difference in this respect.*

Effects on Sea Water of Discharge Therein.

The actual effect on the salt water into which crude water-carried sewage or sludge is discharged is still a matter of much controversy, and further extended experiments are necessary before any definite and final solution of the question can be arrived at.

From the experiments of Professors Adeney, Letts, and others, on the effects produced by *crude water-borne sewage*,

* This may be a suitable place to mention that vegetables, watercress, and fruits grown on the ground should not be cultivated in any situation to which crude or unsatisfactorily-treated effluents may gain admission, because of any pathogenic organisms therein which may thrive and multiply. It must be borne in mind that large quantities of excrementitious matter need not, of necessity, be the causation of infectious disease cases, and the proximity of one or more isolated dwellings, or of fields to which cattle gain access, may be responsible.

when discharged into the sea, or an estuary, it would appear that this method of disposal is not so hygienically sound as has been thought. The influence of the salts present in the sea water, although the latter is very much greater in volume than the sewage flow, is not productive of a very speedy oxidation of the varied organic solids contained in the sewage, and as the growth of the organisms, which bring about the process of nitrification, is impeded, it is considered by some to point to the need for prior treatment of the crude water-carried sewage, with a view, as far as practicable, to destroy those compounds which exercise such an inhibitory influence on the usefulness of the nitrifying bacteria.

On the other hand, it is of interest to compare the influence of sea water itself on *sewage sludge*. From the evidence of Professor F. Clowes, D.Sc., before the Fifth Royal Commission, it would appear that the sea water has but little action as regards its interference with the life of the bacteria. Of necessity, it causes a very considerable diminution in their number, due to the vast volume of sea water into which the sludge is discharged, and which speedily breaks it up into innocuous pieces, and thus prevents any pollution in the water. In such cases, therefore, it is only a question of conveying the sludge sufficiently far out to sea, and away from the influence of the incoming tides, in order that no nuisance may be created on the shores in the vicinity. Whether the sewage is discharged in its crude form from an outfall on shore, or as sludge from a hopper at sea, the matter is usually the means of attracting many sea-gulls, which settle upon it immediately it is discharged into the water. It is preferable in the case of sludge that the dumping area should be carefully chosen, so that the neighbourhoods of edible shell-fish layings are avoided, and in order that they shall not be affected by the action of the incoming tides; further, that no nuisances should be created by their action through the conveyance of offensive matter to neighbouring shores.

Seaweeds and Sewage Discharges.

Volume II. Appendices, Part I. of the Royal Commission on Sewage Disposal (issued August, 1911), contains the minutes of evidence and reports to the Commission in reference to growths of green seaweeds in sewage-polluted estuaries. Its subject-matter possesses, at least, a three-fold aspect, because not only has it a bearing upon the discharge of crude sewage, or imperfectly "purified" effluent into estuaries, and the possibility of detrimentally affecting the waters therein and the shores upon which the various currents may carry it, but there is the consequent interference with the amenities of communities and private owners, the pollution of any edible shell-fish layings, and infringement of the provisions of the Rivers Pollution Prevention Act, 1876.*

The inquiry and experiments in question were consequent on a serious effluvium nuisance which had occurred for many years in Belfast Lough. The sewage of Belfast has, for a prolonged period, been dealt with by screening and sedimentation, and turned into the Lough, together with crude sewage. The nuisance has appeared to coincide with this period, and was not apparent before.

Extended observations and experiments established the fact that the nuisance could be referred entirely to rotting green seaweeds, the chief of which belong to that class of marine algae known as the *Ulva latissima*. It appears that their growth is remarkable during spring and summer in sewage-polluted sea water, and fresh ulva taken from mud banks in Belfast Lough (the chief nursery there of these algæ, where the water flowing over is polluted to the extent of 1 per cent. with the sewage of Belfast) was found to contain over 4 per cent. of sulphur, as compared with 0.46 per cent. in sewage sludge.

It is interesting to note that this class of green seaweed is not peculiar to any particular neighbourhood, but is present also in the sea in the vicinity of the Giant's Causeway and on the Devonshire coast, and elsewhere round the British Isles, as well as on the Continent. Further, the presence of the *Ulva latissima* is evidence of sewage pollution. Its luxuriant growth is due to the presence of sewage-polluted water, as is evidenced by its great increase in parts of Belfast Lough since the pollution of the Lough by sewage. At the same time, it seems clearly established that "purified" sewage is also conducive to the growth of ulva. Hence the complex nature of the subject.

A decidedly interesting feature in connection with the *Ulva latissima* is that they require something to which to attach themselves, and this anchorage has been found to be usually other than mud, and generally on rocks or other solid bodies. This class of marine algae also shows a predilection for the shells of mussels (either dead or alive). The live

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* See p. 292.

mussels usually attach themselves to the ulva by "byssus" threads, which they throw out. Mussels are often found in polluted waters. Indeed, they seem most prolific therein, and appear deliberately to attach themselves to the *Ulva latissima*.

Professor Letts suggests some sort of symbiosis of the ulva and the mussel, that the ulva gets its nutriment partly from the excreta of the mussel, and that the mussel eats the small creatures which are attracted by the ulva.

In situations where sewage effluents have to be discharged into sea water, there seems every indication that the removal or destruction of mussel beds will bring about the prevention of the growth of the ulva (for the production of which they form great nurseries), and thus prevent their annual rotting and consequent nuisance. Farmers occupying lands in the vicinity of the ulva growths in Belfast Lough take a certain amount of it away in carts to put on the land as manure.

The difficult point to determine, however, is the means to employ to get rid of the mussels. Experiments at Belfast with sulphate of copper, on an area of 37 acres densely covered with mussels, and where ulva had commenced their annual growth, had no lasting effect. Where, however, mussels were buried in trenches *in situ*, the particular area has, in the words of Mr. H. A. Cutler, M.Inst.C.E., the Belfast City Surveyor, "practically ceased to be a nursery for growing weed, and that the organic mud has disappeared."

With regard to the effect of clearing off mussels, in greatly reducing the growth of *Ulva latissima*, Southend is an interesting and useful case in point. For, as a result of such clearance, the ulva was washed away by the tides.

The subject is one to which much knowledge has been added by the investigations of the Royal Commission. But its labours should by no means end with the Report just issued, for it is a matter of much importance to all sanitary authorities whose areas are situate on estuaries and the sea coasts where sewage effluent is discharged, as well as to riparian owners and proprietors of edible shell-fish layings so situated.

CHAPTER XXIX.

The Fifth Royal Commission and the Pollution of Rivers and Streams.

The dangers arising from the admission of crude sewage or imperfectly-treated sewage effluent from sewage disposal works into streams have been placed by the members of the Fifth Royal Commission on Sewage Disposal, in their Fifth (1908) Report, under the following heads:—The de-aëration of the water of the river, with consequent injury to fish; the putrefaction of organic matter in the river to such an extent as to cause nuisance; the production of sewage fungus and other objectionable growths; the deposition of suspended matter, and its accumulation in the river bed or behind weirs; the discharge into the river of substances, in solution or suspension, which are poisonous to fish or to live stock drinking from the stream; the discoloration of the river; and the discharge into the river of micro-organisms of intestinal derivation, some of which are of a kind liable, under certain circumstances, to give rise to disease.

The specific organisms of typhoid or enteric fever, and other water-borne infectious diseases, come especially under this heading, and, from the standpoint of public health, the presence of pathogenic (disease-producing) bacteria in potable waters, and in those devoted to edible shell-fish layings or watercress growing, are likely to be the causes of serious outbreaks of typhoid or other water-borne infectious disease. The discharge of crude sewage, or insufficiently purified effluent, into streams is also most likely to be the causation of nuisances, especially in hot weather, by undesirable growths, or otherwise, and thereby constituting a danger to public health, which cannot be lost sight of.

With all the advances which have been made, both in chemical and bacteriological knowledge, since previous Commissions of inquiry into methods of sewage disposal and their influence on the pollution of streams, the last appointe Commissioners have reluctantly to admit that of all the various processes advocated for sewage treatment, or for the purification of water polluted by excrementitious matter, not one can be considered sufficiently satisfactory to warrant its employment for the purpose of rendering a water so polluted fit for dietetic purposes; and they fell back upon the opinion of the 1868 Commission, that "rivers which had received sewage, even if that sewage had been purified before its discharge, were not safe sources of potable waters."

Many methods have been suggested whereby various undesirable organisms may be removed both from potable waters and those used for edible shell-fish beds; but they are either almost, if not quite impracticable on a large scale, or are too expensive.

Sterilisation of the effluent to be so discharged is among them. This is not the place to discuss pros and cons. of the matter, save to refer to a proposal, relevant to this subject, which has been advocated by some of the highest authorities thereon, and supported by the writer on other occasions,* that, assuming the ultimate formation of the anticipated National Water Board and the mapping out of the water-bearing areas of the United Kingdom for allocation to different communities as the needs arise, rivers and other streams that are liable to pollution from sewage or otherwise should not be drawn upon for the supply of potable water to the inhabitants of any district.

In the absence of such alteration in the law as regards the prohibition of the use of the water of streams for dietetic purposes, the question arises:—On whom shall the duty rest of securing the attainment of a sufficiently high standard in the water to fit it for such use? The authority owning the disposal works, by taking, in the words of the Rivers Pollution Prevention Act, 1876, "the best practicable and available means," which, in the present state of scientific knowledge, are, with some classes of effluents, not reasonably possible, or the authority or company drawing upon the waters of the stream for the supply of their district?

The writer, despite the fact that the latter method has apparently the greater number of advocates, favours the former suggestion, feeling, in the words of an opinion which he expressed in 1906,† that this latter suggestion "seems, perhaps, somewhat unreasonable, and if such a state of things became recognised, it is quite possible that in time the water drawn from such a stream would become so impure in

* Surveyors' Institution Professional Notes, vol. XV., part III. March, 1909, p. 252, etc

† "Modern Sewage Disposal: A Popular Handbook," pp. 98, 99.

consequence and contain so many pathogenic germs, that it might be expedient to resort even to sterilisation to render it pure enough for domestic use." In the present state of scientific knowledge on the subject, as we have noticed above, sterilisation is outside the bounds of reasonable practicability.

Despite the fact that the growth of such knowledge has resulted in the discoveries of higher standards of purity which can be ensured in sewage treatment, and that, judged both by chemical and physical tests, the effluents, both from land and artificial methods of treatment, are in many cases very good, yet they are liable to contain germs derived from the human intestines; and any means which it might be possible to employ to render effluents fairly pure bacteriologically would be impracticable on account of the cost of the additional treatment. The possibility of the results not being such as were anticipated must also be borne in mind, as the consequences accruing from the false sense of security created thereby might be serious.

Sewage contamination has been, and is likely under present circumstances to continue to be, not only a source of danger as regards drinking water supplies and water used for edible shell-fish beds, but also to land used for watercress, vegetables, and fruit-growing, to which crude sewage or imperfectly purified effluent is applied or obtains admission. It is not always the case that large quantities of sewage are to blame, for contamination may take place through cattle, or the proximity of farms, stabling or dwellings, the excretal matter from which finds its way to the beds and garden land on which any pathogenic organisms present therein thrive and multiply.

Crude sewage and effluents from chemically—or bacterially—treated sewage are usually discharged into streams adjacent to the disposal works, which are either themselves drawn upon for the supply of some community lower down, or frequently communicate with some other waters which serve such a purpose.

In December, 1910, the Report of the Joint Select Committee, appointed by both Houses of Parliament, dealing with the Water Supplies Protection Bill, was issued. Whilst it is most likely that little more will be heard of the Bill, the recommendations of the Committee merit consideration. The Committee refer to the specific recommendations as to the creation of a National Water Authority, contained in the reports of the Royal Commission on Sewage Disposal, and go on to say they "cannot find that any effective action—they may say, indeed, any action at all—has been taken on these repeated recommendations."

Then the Committee strongly recommend, firstly, a Central Administrative Authority, either a branch of the Local Government Board, or otherwise, and, secondly, the division of the country into water-shed areas, with Rivers Boards for each, "who, subject to the guidance and control of the central authority," shall secure the preservation of water supplies within their jurisdiction from pollution, and also advise on their allocation for sanitary, industrial, and other purposes.*

* The writer in the Journal of the Institute of Sanitary Engineers, January, 1911, p. 94.

CHAPTER XXX.

Other Methods of Pollution.

Although the most serious pollutions of the waters of rivers and streams are due to crude sewage or effluents, they are liable to pollution in many other ways.

Percolations from leaky cesspools, or the discharges from the closets of isolated houses or from stabling, on river banks, or adjacent thereto, may lead, from time to time, to grave danger through the entrance of water-borne disease germs. Again, there are possibilities of further dangers or nuisances arising through their waters traversing agricultural districts, or draining urban or manufacturing areas, the chemical and other wastes from which may give rise to serious nuisances.

To What Extent Do Running Streams Purify Themselves?

In the case of running streams, it has been considered by many that practically all traces of contamination are most usually lost some three miles below the point of discharge. Others contend that is not actually so, and that the clearness in the water which is frequently apparent is not due to the waters of the stream having regained their purity by some chemical or bacterial action, but that this clearness is due, chiefly, to the settlement of the solids in suspension to the bed, whilst any undesirable micro-organisms which may have obtained admission to the stream with the discharges, still remain in the water itself, in full possession of their powers of doing harm. Where, however, river water can be stored for some time before being used for dietetic purposes, any microscopic organisms of water-borne disease gradually die when they have to contend in the struggle for existence with the bacteria ordinarily present in the water. There is thus a practical inability of such bacteria to multiply in water, and if it can be stored for weeks, or months, the possibility of any harmful species surviving is very remote.

The Question of Standards of Purification for Sewage Effluents.

Really to ensure the discharge of a satisfactory effluent from sewage disposal works, at least one of two standards of purity ought to be a *sine quâ non*—a chemical or bacterial one, depending on whether the discharge is into potable or non-potable waters; or whether the discharge is to take place in the vicinity of edible shell-fish layings, or in such a position that any considerable portion can reach them.

For these reasons, hard and fast and generally applicable standards are not only unattainable, but undesirable, if not, indeed, altogether unnecessary. Under many circumstances, local conditions must be taken into account, and the attainment of a very high standard in streams flowing through manufacturing districts, and receiving the discharges from the factories in the vicinity, is not as necessary as, for instance, in the case of those flowing through rural or purely residential ones. The former, most likely, will not be, whilst the latter may be, the source of potable waters for one or more centres of population. Another question would be whether any interests of the neighbourhood were affected by the discharge. The state of the stream in the vicinity of the outfall would also be a factor for consideration.

In this connection the Fifth Royal Commissioners, in an Interim Report, issued in 1901, said:—"We consider it of the utmost importance that the simplest possible means should be provided for adequately protecting all our rivers, and we are, further, of opinion that it will be desirable, probably for some time to come, that scientific experiments should be carried on in order to ascertain all the real dangers of pollution against which they should be protected."

As has already been observed, present scientific knowledge, especially of bacteriology, prevents this now being done with any accuracy.

The same reason operated to prevent full compliance with the terms of the Rivers Pollution Prevention Act, 1876; and as, apart from the question of drinking waters, it is not considered that the public health is endangered by the presence of noxious organisms in a river, and that its amenities are not necessarily destroyed thereby, there has all along been a tendency for the authorities thereunder (the County Councils and the River Boards) not to press their powers under the Act unduly.

In their Fifth Report, issued in 1908, the members of the above-mentioned Commission, whilst saying that, pending the completion of certain observations, especially on the taking up of oxygen from the water into which sewage or effluent discharged and the consequent fouling, they did not propose to report finally on the question of tests and standards, they made the following provisional remarks in connection therewith, for the guidance of local authorities, viz., "That effluents should not contain more than three-parts per 100,000 of suspended matter." They also made some suggestions as to the weight of atmospheric oxygen, and as to the parts by weight thereof.

CHAPTER XXXI.

The Addition of Manufacturing and Trade Wastes to Sewage.

Under Section 4 of the Rivers Pollution Prevention Act, 1876, which applies to the United Kingdom, liquid manufacturing wastes must not be discharged into any river, stream, canal, lake, water-course, or the sea, unless the manufacturer can show to the satisfaction of the Local Government Board that in each case the best practicable and available means are being used to render harmless the poisonous, noxious, or polluting liquids discharged.

With a view, as far as possible, to prevent this fouling of streams, etc., the same Act enacts that local authorities are to give facilities enabling the manufacturers of the district to discharge the liquid wastes produced in their manufacturing processes into the local sewers. But the facilities are subject to the proviso that no sanitary authority shall be obliged to admit into their sewers any liquids which would prejudicially affect such sewers, or the disposal by sale, application to land, or otherwise, of the domestic sewage matter of the district, or which could be, in any way, injurious from a sanitary point of view. They may also refuse such facilities where the sewers are only sufficient for the requirements of the district.

Until quite recently the difficulty of treating domestic sewage combined with manufacturing and trade wastes of different kinds, consisting of various chemicals, fats, dyes, waste, liquors, from tanneries, breweries, etc., very effectively stood in the way of local sanitary authorities giving the requisite facilities, and hence litigation was not infrequent. Trade wastes, therefore, continued to be discharged into the nearest water-course, which, in consequence, was little better than a sewer, and, especially in bad weather, most offensive in smell—and at all seasons objectionable in appearance.

Now, however, the difficulties of treating domestic sewage combined with trade effluents have been largely overcome in most cases. It would be possible in many instances for the liquid wastes from factories to receive some sort of preliminary treatment prior to discharge into the local sewers, and in such cases the wastes should be required to reach certain chemical standards.

Practically all such liquid effluents retard the purification of sewage to a greater or lesser extent, and in most cases necessitate some modification in the method of treatment adopted.

Treatment of Mixed Sewages.

As an illustration of the difficulty of treating a "mixed" sewage, containing brewery, tannery, and manufacturing refuse of an organic character, the Exeter installation may be referred to. There the discharges from some 12,300 water closets and the ordinary household wastes, road washings, etc., are mixed with waste liquids from four breweries, one large tannery, and two paper mills. This sewage, which amounts to an average dry-weather flow of 1,300,000 gallons per 24 hours, is treated by closed septic tank and single contact bed, followed by land treatment of the effluent therefrom on some sixteen acres of land, which has a heavy surface soil overlying a loose gravel subsoil. This treatment of the mixed sewage is considered unsatisfactory.

At Guildford, a strong domestic sewage, with the addition of about one-fourth its amount of brewery refuse and other liquid trade wastes, is treated in two different ways:—(1) Chemical precipitation by alumino-ferric, in quantities of about eight grains per gallon, followed by application of the tank effluent to some twelve acres of land, the nature of the soil and subsoil being mostly gravel, with some sand, drained to a depth of 6 feet. The effluent from this process is not of a very high quality. (2) Open septic tank and double contact on beds having 2 feet 6 inches of material, followed by continuous filtration through shallow percolating filters, 2 feet to 3 feet 10 inches in depth.

Comparing the two methods of treatment, it was found that the septic tank liquor lends itself more readily to purification than the imperfectly clarified precipitation liquor.

On the whole, the results are described as "good."

It should be noted that a large proportion of the solids in suspension in sewages which contain brewery and tannery waste or wool scouring liquors are difficult to settle.

Separate Disposal of Trade Effluents.

It is anticipated that the Fifth (and present) Royal Commission on Sewage Disposal will shortly issue a report dealing with the treatment and disposal of trade effluents, apart from domestic and general town sewage, and also the disposal of distillery waste liquors.

With regard to these matters it has been suggested for some time past that in manufacturing districts, especially where one or two industries form the staple trades of the locality, manufacturers should combine to treat their liquid factory waste at some central spot, and there send the same, and thus relieve the local sanitary authority of any liability, under the Rivers Pollution Prevention Act, 1876, to deal with it in conjunction with the ordinary sewage of the locality.

Were such an arrangement arrived at, it would only be fair to treat such manufacturers in a preferential manner as regards the payment of the local rates.*

* The writer in Surveyors' Institution Professional Notes, vol. XV. p. 247, 1909.

CHAPTER XXXII.

Country Houses and Isolated Public Institutions.

Where these are connected with a local sewerage system, or where it is deemed sufficient to deal with the excrementitious matters by earth closets or cesspools, no difficulty is occasioned. But where such means are unsuitable, or are not available, it becomes necessary to deal with the sewerage by some other means. This necessitates the construction of "treatment" works, similar but on a smaller scale of course than those necessary for disposing of town sewage. The conditions are, in many respects, the same, but some features of peculiar difficulty present themselves, and consequently necessitate some modification in treatment, or the use of some special method.

We have already noticed, in connection with the construction of sewers,* that the longer the distance which water-borne sewage has to travel, the greater is its state of emulsion, due to mechanical attrition, on its arrival at the works. With small installations this is not so, because the distance to be travelled is so short, and the particular microscopic organisms present in the sewage matter have not sufficient opportunity of carrying out any effective work. Again, the sewage matter from such buildings, and especially from institutions, contains so much grease, soap, etc., which, in a similar way to the action of fats in the human digestive system, prevent the free action of the gastric juices on the food therein, militate against speedy and effective treatment by the sewage bacteria.

Grease Traps.

It is preferable, under these circumstances, to make some provision for separating the grease, etc., from the sewage matter proper, as soon as possible after it leaves the premises. One method is to use a grease trap for the purpose.

There are also other more advanced methods in use for the recovery of the grease, whereby it is rendered fit for utilisation, or as a saleable commodity; besides this, the objective of the employment of such a method—the extraction of as much of the grease as is present therein—is attained.

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* See p. 38

The special recovery plant used for the purpose consists of an apparatus very similar in construction and use to sludge-pressing machinery,* a filter press being used for separating liquids and solids.

Other Factors.

In considering the question of effectually treating and disposing of the sewage from buildings separate from any system, other factors have to be borne in mind as regards methods to be followed. The only satisfactory one, and one preferable in every way, is the employment of some form of bacterial system for the breaking down of the suspended organic solids.

It is true that chemical precipitation is in many respects more satisfactory in the results produced, in that the sedimentation brought about is usually more effective, but as this necessitates the employment of manual labour, it is, generally speaking, inadvisable to suggest its adoption.

It is useful to bear in mind that disinfecting chemicals should be used very sparingly, if at all; because, with very few exceptions, they interfere with the work of the sewage bacteria.

Size of Installation.

With institutions, it is usually possible to ascertain the number of persons who will be housed therein; but with private houses or mansions this is most usually a matter of considerable difficulty, and the sewage engineer has to make a guess at it. With institutions, the work should be constructed for treating the sewage for the maximum number which the building is constructed to hold; with private premises, the class of house should be considered, and the habits of its possible occupants are factors in its determination. For instance, bed-chambers in poorer class dwellings will be used by more persons, in proportion to their size, than those of the well-to-do, and the mansions of the rich will be occupied by far less persons in proportion to their size. Yet again the latter will, from the use of a number of baths, lavatories, etc., have a greater amount of water to dispose of.

These are all factors in determining the size of the works.

The used water from baths, lavatories, etc., as well as the rain water, should be kept entirely separate from the

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* See p. 147.

crude sewage proper, and should be carried away in water-tight pipes, to a suitably constructed storage tank, from whence it can be pumped for use as needed, in gardens, or otherwise.

Having, as far as possible, decided as to the number of persons, the sewage from whom the new plant will be required to deal with, it is necessary to bear in mind the area of a filter bed required for that number; and, in fixing this, the fact should be kept in mind that, similarly to towns, there are particular hours of the day during which by far the greater quantity is sent down. In private installations the difference is necessarily much more marked, and during by far the greater part of the day there is but little more than a trickle passing through the pipes to the works. When the flow of sewage is uniform, a properly constructed filter bed should be able to treat the sewage from fifteen persons on each cubic yard; but half as much again should be allowed for where the flow is intermittent in character. In making these calculations a horse should be considered as equivalent to five persons.

Septic and Other Bacterial Methods.

As has been observed, these systems are more suited to the cases with which we are dealing. Tanks, in which the sewage can be received, held up, and septicised, have to be constructed on similar lines, though, naturally, of much smaller proportion, than those in use in town installations. Whether they should be closed or open must be decided, and their proposed situation, and extra cost, which is an important item in the construction of small works, must be taken into consideration. In the near vicinity of houses an open tank in which sewage was being septicised would be as big a nuisance as the proximity of a much larger plant.

The amenities have also to be borne in mind. With cottages and smaller residential property, the choice of a suitable site will, in most instances, be a matter of some difficulty, and for that reason every opportunity should be taken to make use of the configuration of the land, the presence of a clump of trees, etc., to hide the works. Failing this, the formation of a high bank of earth, or planting shrubs and young trees thereon, may serve the same purpose; or some other equally satisfactory method may suggest itself. Especially is this so where the rise and fall of the land necessitate the tank being constructed wholly or partly above ground, instead of being built in excavation. The method to be employed in dealing with the effluent must also be taken into consideration in relation to the water supply, as it is, of course, necessary to protect that which is likely to be used for dietetic purposes. In this connection, the rights and interests of neighbouring occupiers in all kinds of water, and the application of the provisions of the Rivers Pollution Act, 1876, must be studied.

Use of Effluent.

In this connection, another factor has to be borne in mind. As the effluent contains valuable manurial properties, in that its constituents comprise phosphates, potash, nitrates, etc., it may be desired to make use of the liquid effluent in this way, and, consequently, some provision may have to be made for its storage in a watertight chamber, provided with a pump or other means of emptying when needed. Its size will depend on circumstances, in calculating which it is essential to remember that six and a-quarter gallons occupy a cubic foot of space. Land may be used for the reception of the tank effluent, if sufficient is available, and it can be usefully or economically employed thereon, otherwise it should be treated on contact beds, or in trickling filters, with fixed or movable distributors.

CHAPTER XXXIII.

Country Installations. Automatic Appliances.

Where small works are concerned, it is obvious that economy must always be taken into account, so long as it does not interfere with efficiency. Therefore, it is apparent that the working of the installation ought not to be left too much to manual labour; besides which, this would in most cases be of the unskilled class. In a country house or institution the services of a groom, porter, or other servant are usually requisitioned for looking after the sewage treatment plant, consequently it is essential, as far as it is reasonably practicable, to employ automatic appliances of as simple and as easily worked design as possible. Even in cases where the operations left to manual labour are very simple in their nature, and especially if it is necessary to perform the same by night as well as day, there is the possibility of the changes not being carried out with that regularity which should be an essential feature. Consequently trouble would most likely result from any irregularity in working, which might cause both expense and annoyance in many ways.

Chief among the points in the workings of installations on a small scale are the opening and closing of various valves, and several very useful automatic appliances are to be had to take the place of human manipulation; and so long as clear, simple, and concise directions are given in regard to such arrangements as can only be carried out by manual labour, there is no reason why such should not be carried out very effectually by an unskilled hand. Among the automatic gear which may be usefully employed in the working of small installations may be mentioned that for the ponding and release of the tank effluent. This may be of simple construction, comprising simply supply valves, a weighted lever, and a float on each of the other valve rods, similar in many respects to those employed in larger installations. These apparatus will be dealt with more fully later.

Perhaps the factor of greatest importance in small installations, especially those for country houses, is the amount of personal attention the plant requires. No installation can be left absolutely to take care of itself, but a good septic tank and distributor and filter for a country house, or small hospital, do not usually need attention oftener than about once a month, and filters with suitably graded media as shallow as from 3 feet to 4 feet may be relied upon to give effluents always capable of standing the usual tests.

To secure the greatest amount of work from any filter, it should neither be overworked at any time, nor left idle for many hours, and a fairly uniform flow day and night can be secured in the septic tank if the tank outlet is restricted to pass the average rate of flow.

"Lifting" Sewage at Small Installations.

Where the contour of the ground renders it necessary, "lifting" the sewage will have to be provided for. In the case of small works, it is essential to introduce as simple apparatus as possible. The motive power employed may be automatic; or a gas engine, electric motor, windmill, or other power can be used.

A Simple Design.

It is not by any means necessary to follow any particular "system" in laying down an installation, especially where very small tanks are concerned, particularly where it is intended to pass the tank liquor on to land, or to receive it in a storage tank for subsequent use. In that case, all that will be needed will be a suitably constructed tank, which, as in case of larger ones, and, depending on the rise and fall of the land, may be constructed either in excavation, or wholly or in part above the level of the surrounding land, as it is far cheaper, other factors being equal, to lay pipes so that the tank may be fed by gravitation than by pumping; for besides the capital outlay, there is the annual cost of maintenance, fuel, and attention. The tank should be built of concrete, or brickwork in cement, faced with cement, and rendered inside with cement also. When in the vicinity of houses it should be covered with a roof supported by brick arches, which, especially if it is on or near the ground-level, can be covered with a layer of soil. In this latter event, the sides of the excavation should also be provided with at least six inches of well puddled clay. As regards its form of construction, a small tank should be at least three times as long as it is broad, say, 3 feet by 9 feet, and 6 feet in depth. This will give a capacity of some 1000 gallons. It will be easy to understand the reason for this shape of tank, when it is realised that where small quantities of effluent are concerned, the difficulty is to prevent the outlet being too near the inlet, in order to avoid disturbance of the bacteria, and also the escape of any of the organic solids in suspension, on which these microscopic organisms are at work.

Where further treatment of the tank effluent is to be carried out by artificial means, a small contact bed may be constructed, to which the tank effluent may gravitate. The method of construction in puddling and material should be the same as described above for the tank.

The bottom should be made with a slight fall to the outlet channel, and in it should be laid a series of channel pipes, in herring-bone formation. On this should also be laid the filtering medium of coke breeze, clinker, flints, or such other suitable substance as can be easily and cheaply obtained.

Approximate Cost.

This will, in most cases, be an item for consideration. The object of the installation should, however, be always to the fore, and a slight saving in cost of construction would not compensate for unsatisfactory results.

Given reasonably favourable conditions as regards the choice of the site of the works to which the sewage can gravitate, the cost of constructing the works and covering the incidentals should not usually exceed 5 per cent. on the value of the house concerned. When, however, it is found necessary to "lift" the sewage, the cost may come up to 10 per cent.

In round figures, it may be said that £60 should provide an installation on simple lines for treating the sewage from a dozen persons, reckoning, say, twenty gallons per head; and £150 for works to treat that from fifty persons. These figures can only be considered as approximate, as practically every case should be a subject for separate consideration, in which any special features can be dealt with.

CHAPTER XXXIV.

Some Systems for Small Installations.*

The Stoddart System.

We have already discussed this system in some detail in connection with large works,† but it is also suitable, with necessary modifications, to the treatment of sewage from separate houses, mansions, workhouses, schools, hospitals, and other public and private institutions.

Tank and filter beds are employed. The former differs in construction, to some extent, from the usual kind in use in small installations, having a series of submerged walls, and scum-boards fixed therein, which are adjusted in such a way as to cause the incoming current of sewage to clear both scum and deposit, and, at the same time, to take an alternately ascending and descending, as well as a longitudinal course. For cases where open tanks are used, the scum boards serve also to exercise a moderating influence on the wind, and check its disturbance of the surface of the effluent in the tank, and consequently prevent the disturbance of the bacteria at work on the organic solids therein, which would retard the liquefaction.

It it is desired to divide the tank into two compartments, the first submerged wall can be carried above the surface.

The continuous filter is connected with the tank by means of a channel, in the throat of which is fixed a diaphragm, which is intended to regulate the flow of the tank effluent in small works, the object being to counteract the irregularities in the quantity of its flow, as this is always a source of trouble in the case of small installations. This is not, however, an altogether satisfactory method, because it is considered almost impossible to avoid over-putrefaction taking place.

The incoming tank effluent is fed to the surface of the filtering material of the bed in a film-like liquid, through the distributing apparatus, which is *fixed* immediately above

* One or two methods only are here described. There are several other useful ones.

† See p. 82.

it. The apparatus consists of sheets of specially corrugated metal, each of which feeds two square yards of the bed; each is provided with a number of notches, which are cut out of the ridges, and having on the under surface a series of drip-points, some 360 to the square yard.

The sketches in Fig. 16a* will illustrate the particular features of Mr. Stoddart's Patent Continuous Filter. The specially designed cast-iron supply channels (B) are provided with solid lugs for the purpose of bolting them to the distributor ends. The distributor, by the way, is the only portion of the apparatus which cannot be made irrespective of the patentee, but must be purchased from him.

To prevent the emission of smells, the filter and distributor can be enclosed in box covers. No periods of "rest" are necessary, according to the patentee's ideas. These filters should be constructed highest in the middle, with a fall of 1 in 36. The floor should be of concrete, faced with cement. The collecting channel for the filtered effluent is placed outside the filter, as shown at K, Fig. 16.†

Figs. 21 and 21a illustrate plan and section of filter designed by Mr. Walter Stoddart, suitable for a small installation, showing its chief features and connection with tank.

We have before noticed that the contour of the ground and the need for constructing the filter in such a position that the tank effluent will gravitate thereto may call for its being built entirely above the surface of the ground. Fig. 16‡ shows one of Stoddart's in this position, and at the same time the various parts of the Stoddart Filter. The tank is rectangular, and at least three or four times as long as broad. At times this difference is increased to as much as ten to fifteen times. The customary depth is six or seven feet.

On the other hand, the contour of the ground and the need for gravitation may, as it generally will, call for the installation to be built partly, or entirely, in excavation.

Fiddian Revolving Distributor.

By means of the Fiddian Distributor the sewage is sprinkled from the revolving buckets of a long water-wheel, 18 inches diameter, which covers and rolls over the surface of the filter, being supported by one or more rail tracks and fed by means of a pipe fixed alongside, or above, the water-wheel.

* See p. 86. † See p. 84. ‡ See p. 84.

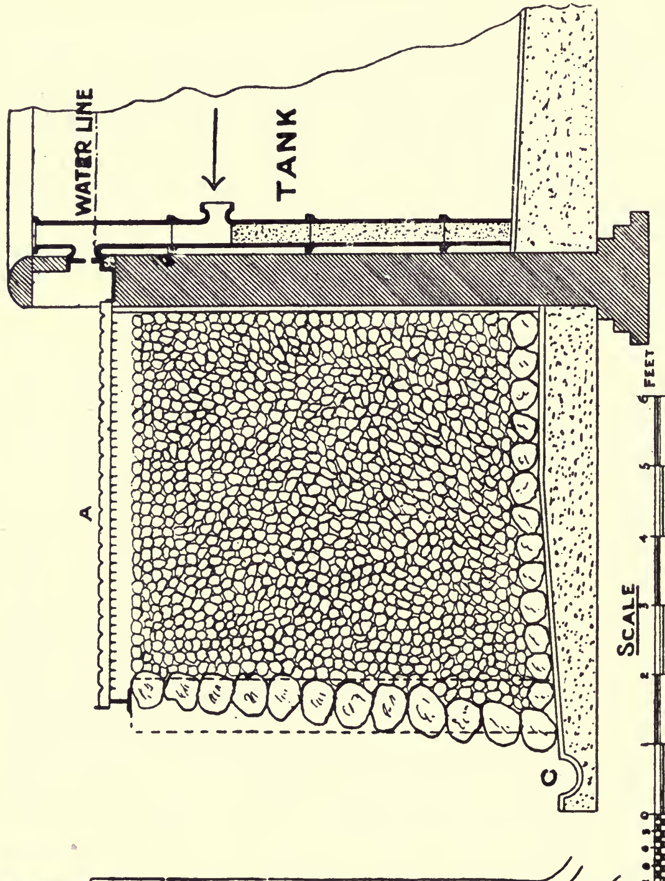


Fig. 21. Plan of Stoddart's Small Filter.

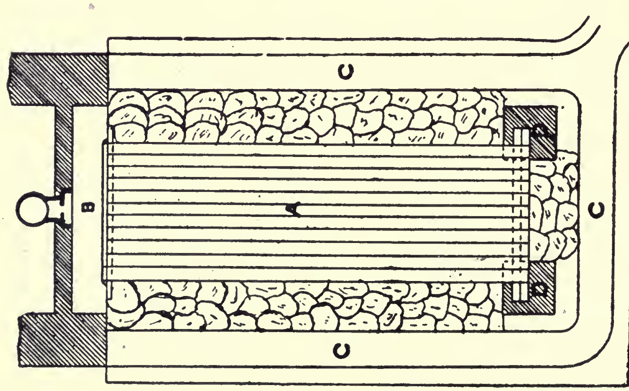


Fig. 21A. Section of Ditto.

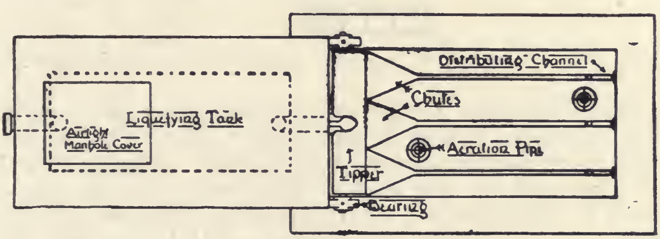
This system is now employed for both circular and rectangular filters. The circular ones may be of any diameter from 8 feet for small installations (as Fig. 19, but with a single drum) to over 100 feet for town works, and the rectangular ones, fed by a single drum, may be as much as 200 or even 300 feet long. (See Figs. 19 and 20.)*

On circular filters, over which the arm, or arms, of a distributor revolve, the motion of the arm near the centre is much slower than it is near the circumference, and the quantity issuing from every part of the arm should be regulated accordingly. This is done, on the Fiddian distributor, by means of weir plates with varying widths of opening and controlling the delivery into each compartment of the water-wheel drum.

Another feature of this type of distributor is, that the smallest dribble falling into the buckets of the water-wheel remains until its weight is sufficient to revolve the wheel. For small installations an advantage is also claimed that there are no small holes liable to be choked by the suspended and colloidal matters in the sewage, the waterway being free and unrestricted throughout.

Farrer's Stationary Distributor.

This apparatus consists of a wrought-iron tipper, fed by the incoming sewage. In the smaller kind, the tipper is of single sections, whilst larger ones are divided longitudinally



PLAN

Fig. 22. Plan of Farrer's Single-section Distributor.

into two halves, so balanced that when one half has been filled the centre of gravity is displaced, and the tipper discharges into the fixed series of chutes and distributing channels, which are perforated at their lowest points with

* See pp. 91 and 92.

¼-inch holes, at 3-inch centres, and the sewage which is carried along the various parts is sprayed through these holes over the filtering media.

The "head" of effluent from the tipper is relied upon to clear the holes in the chutes and channels, and to ensure an invariable and even flow.

The Farrer Distributor, illustrated at Fig. 22, is adapted to a filter of approximately 8 square yards, and is calculated

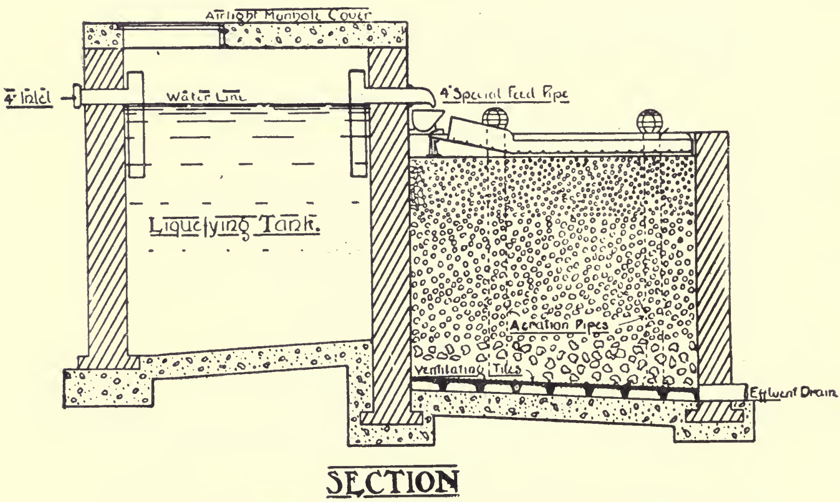
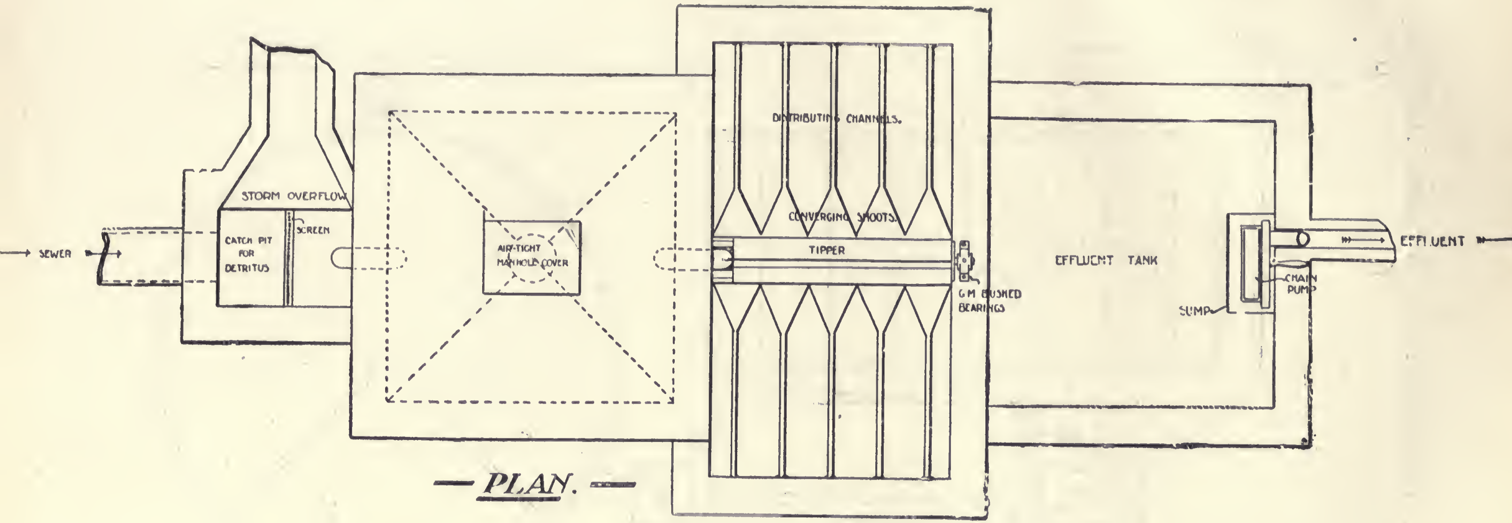


Fig. 22A. Section of Farrer's Single-section Distributor.

to deal with some 150 gallons of sewage per day, whilst Fig. 22a shows section of same. Fig. 22 is a plan of bed with single section distributing channels. Figs. 22a and 22b illustrate plan and section of an installation showing a tipper of double section with distributing channels and converging chutes. The floor of the filter is laid with ventilating tiles, from which 4-inch earthenware pipes are carried above the surface to serve as aerating shafts.

Plan of Small Sewage Disposal Works.

The outline plan (Fig. 23) illustrates a small installation supplied with Messrs. Kent's regulating valves. The sewer discharges into the chamber (F), provided with a fixed weir overflow, so arranged that a sewage flow exceeding six times



— PLAN. —

Fig. 22B. Plan of Installation with Farrer's "Tipper" of Double Section.

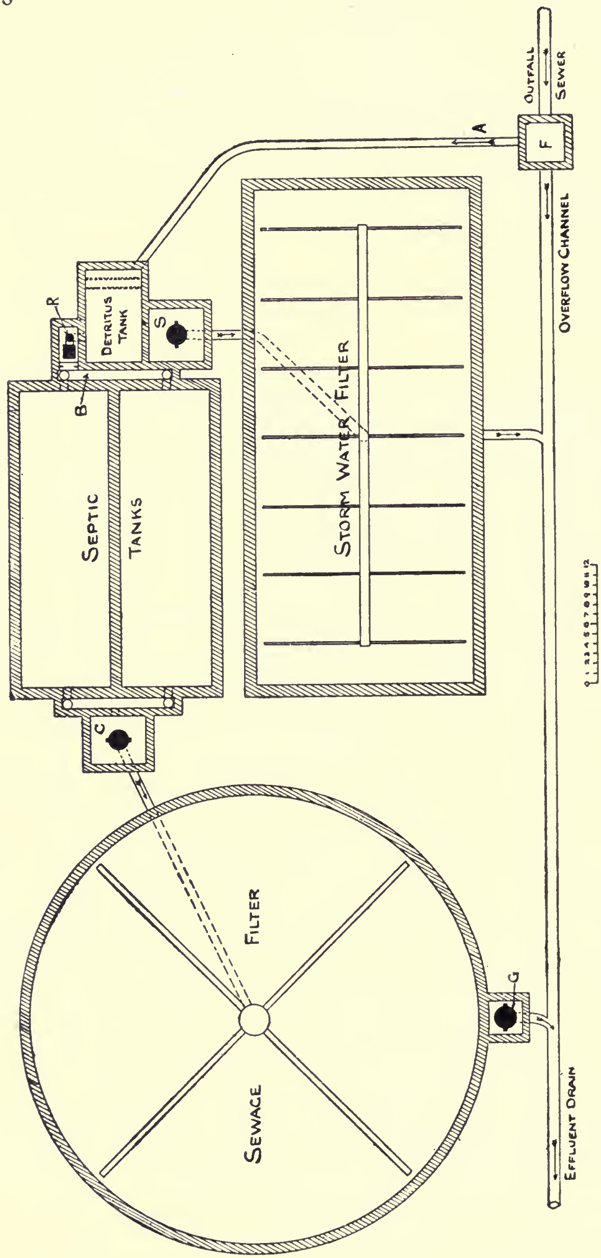


Fig. 23. Plan of Small Sewage Disposal Works showing Application to the various Valves.

the normal is turned from the pipe (A) into the detritus tank, from whence it passes into the regulating chamber (R), having a regulating valve.

In the event of the flow not exceeding three times the normal, it passes through (B), the inlet channel into the septic tanks.

The filtering material is aerated by the use of the valve at (G).

The storm overflow, when exceeding three times the normal, is sent by the regulating valve over the weir into the storm water-dosing tank (S), thence to the storm filters, and lastly to the effluent drain.

The regulating valves are fixed in a special chamber. In works provided with a detritus tank and storm water overflow weir the valve should be placed between same and the septic tank; but if not, the valve should be placed for regulating the maximum flow into the tank.

Messrs. Kent's regulating valve is so arranged as to prevent more than three times the normal flow from passing to the tank.

Small Installation for Country Mansion.

The following describes an installation carried out at a country mansion on bacterial lines (Figs. 24 and 24a). It follows the usual procedure in such circumstances:—

(1) Outfall drain discharging into a small grit chamber with a suitable screen (3).
(2) Storm overflow; (4) valve leading to pump for the collection of sludge.
(5) Two valves which regulate the height of the scum above, to the dosing tanks.
(6) Inlets for effluent to dosing tank.
(7) Stop-cocks controlling inlets.
(8) Dosing tanks.
(9) Jennings' Revolving Sprinklers.

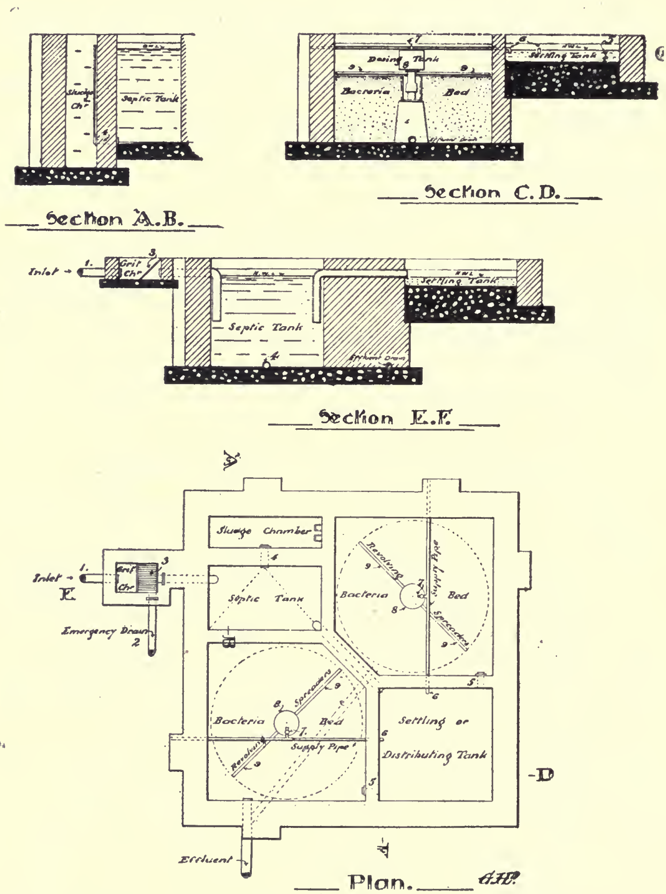


Fig. 24. Detailed Plan of Installation for Country Mansion.

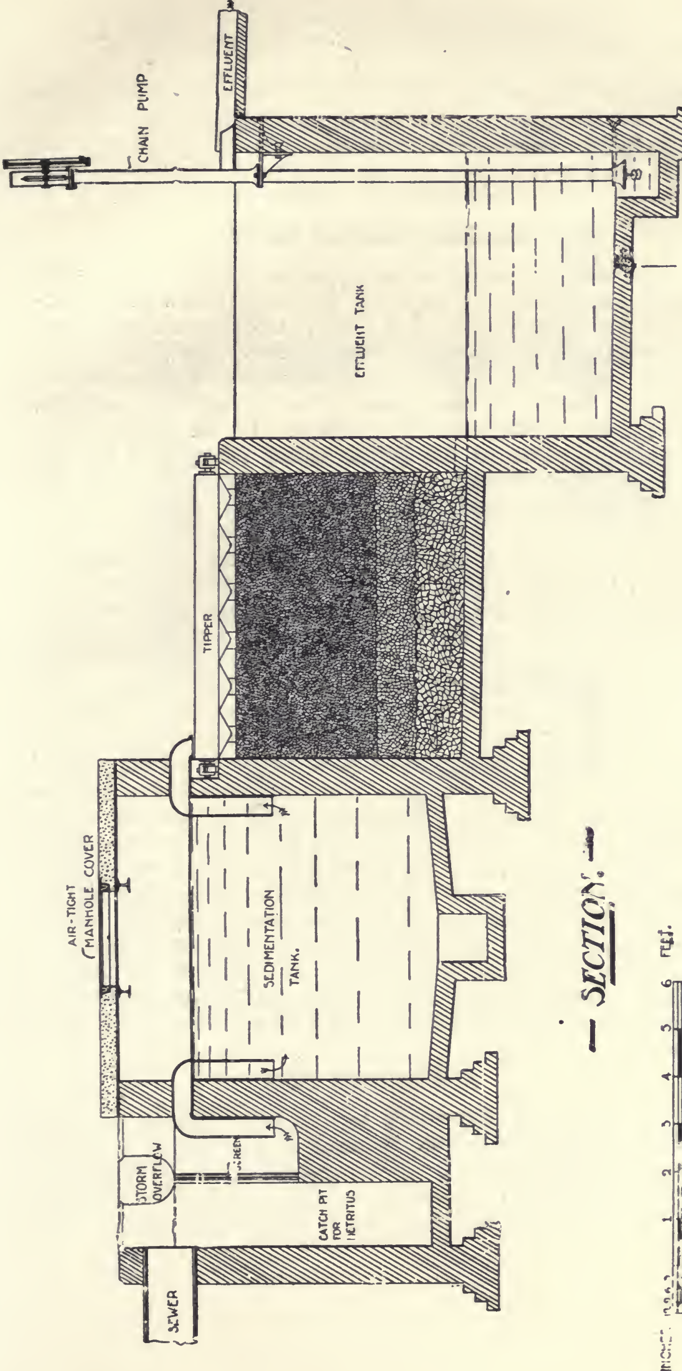


Fig. 24A. Section of Plan for Country Mansion.

CHAPTER XXXV.

Sterilising Infected Excreta.

The evacuations from the bowels of sufferers from some infectious diseases, the specific germs of which are water-borne, are always a source of danger, whether received direct into potable waters, or into their sources of supply, or into sewage, which may be turned into any stream or watercourse which in itself is drawn upon for water supply, or supplies other streams used for that purpose. In the latter case it matters little whether the contamination takes place through the discharge of crude sewage, or imperfectly purified effluent, the danger is the same, as typhoid bacilli possess very great vitality and it is only after prolonged storage in reservoirs that they succumb to the attacks of the water bacteria, which after a time they are unable to resist. Again, where conservancy systems are followed, and the night soil is received into middens or pail closets which are not well covered, flies may act as carriers of the germs and convey them to the human system, through contaminating solid and liquid foods.

Another factor to be borne in mind is that the urine of a typhoid patient is also a source of danger during and for some time after illness, besides which it has been proved during the last year or two that, although sufferers from typhoid or enteric fever are immune from another illness from the same complaint, yet they are liable in some cases to act as "carriers" of the bacillus typhosus for an indefinite number of years—in some few instances as long as sixteen years. The organisms secrete themselves in the gall bladder, and are evacuated with the discharges from the bowels; and unless the hands are washed after attending to the calls of nature, such a person may convey the disease to another, especially through handling and contaminating foods, or in cooking.

A Sterilising Plant.

The last few years have seen a good deal of attention given to this subject, with the result that sterilising apparatus has been devised to deprive the evacuations of sufferers from cholera and enteric fever of the organisms of these diseases.

At Newcastle, this sterilising is effected by steam. Each steriliser is placed close to the ward lavatories, and consists of a pan of 30 gallons capacity; it receives the discharges from a water closet and a slop sink. Two pipes convey the steam into the pan, one of which (sterilising) reaches to the bottom, the other (ejecting) ends inside the cover of the

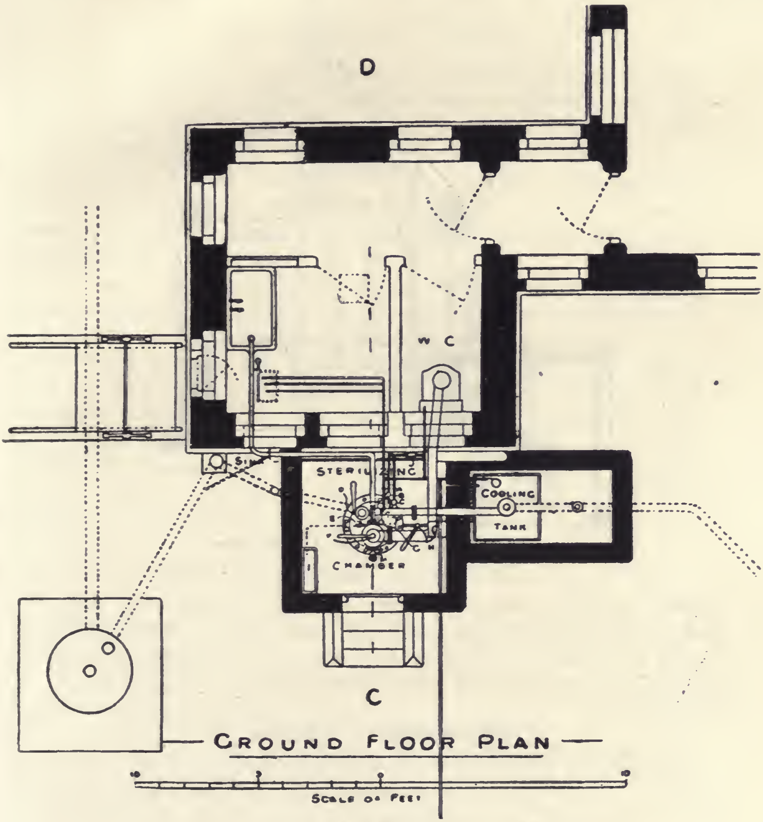
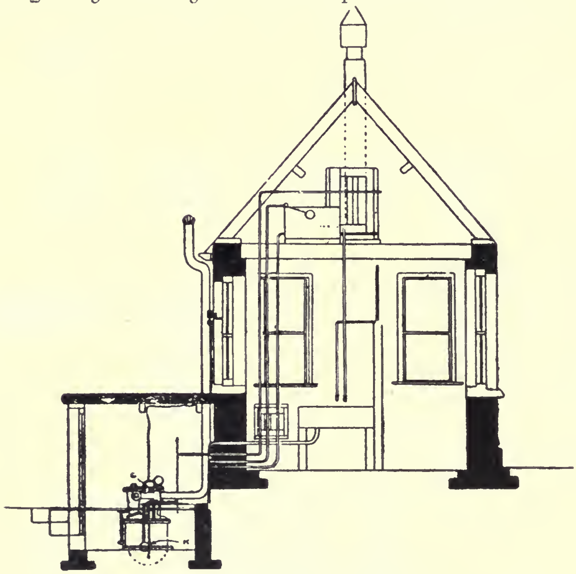


Fig. 25. Plan of "Newcastle" Sterilizer.

pan. The steam raises the temperature to about 250 degrees Fahr. This temperature is maintained for fifteen minutes, which is considered sufficient for the sterilisation of the excretal matter. The steam-cock is then closed and the ejector-cock opened, through which it is discharged into a cooling tank of some 120 gallons capacity. Here it remains for about five minutes, and it is then turned into the drainage system. The pan and pipes are then thoroughly cleansed and sterilised by fresh flushes of steam.

Figs. 25 and 25a illustrate plan and section of the



— SECTION C.D —

Fig. 25A. Section of "Newcastle" Sterilizer.

apparatus in use at Newcastle, which can deal with from 200 to 250 gallons daily from each ward, and which affords ample provision for twenty patients. The makers of this apparatus were Messrs. Goddard, Massey, and Warner, Nottingham.

"Oxychloride" Process.

After many experiments Mr. Samuel Rideal, D.Sc., is of opinion that sewage from hospitals and infirmaries may be freed from dangerous organisms by the use of oxychloride before passing on to the sprinkler or contact beds or land, or before entering into ordinary sewage systems, without in any way interfering with the usual methods of ordinary sewage purification. These discoveries Dr. Rideal made public in a paper which he read before the Faraday Society on February 9th, 1909.

The "oxychloride" process is more fully dealt with in the succeeding chapter.

CHAPTER XXXVI.

The Oxychloride Process.

This is one of the most recent methods introduced with the object of deodorising and sterilising sewage effluents, and for the prevention and removal of fungoid growths, by the application of the oxychloride solution.

The solution is made in a suitably designed apparatus, by means of which a current of electricity is passed from a dynamo through a solution of common salt (or sea water which is naturally more economical).

A machine of this class, 10 feet by 4 feet in size, is capable of making enough oxychloride solution in eight hours to deodorise from 280,000 gallons to double that amount of septicised sewage, the great variation in amount depending on the nature of the effluent. No cost can be given even approximately as the local conditions may vary in every case.

The employment of the "oxychloride" process for the deodorisation of sewage effluents formed part of the work undertaken at Guildford; the Local Government Board having referred the matter to the Fifth Royal Commission on Sewage Disposal.

The chief object of these observations was to decide whether the application of the oxychloride solution to a sewage effluent would interfere with the purifying powers of sewage bacteria.

The conclusions from this series of experiments have been summarised as follows:—

(1) That a bed can be successfully matured when using oxychloride in such quantities as are required for preventing aerial nuisance;

(2) That a bed may be thus matured at a quicker rate;

(3) That this treatment renders possible the use of fine-grade filters, which are usually not available for fear of clogging by growths;

(4) That it also renders easy the clearing of pipes, sprinklers, and syphons blocked by growths, without disconnecting the system;

(5) That any place adopting the treatment for preventing aerial nuisance has the additional advantage of (a) the retarding and destruction of growths, (b) the assistance in the work of oxidating, (c) the means at hand of a very active deodorising and disinfectant agent which may be made use of for general purposes.

The Borough Surveyor of Guildford has been good enough to inform the writer that he is satisfied of the value of this process. It would appear to be very useful where a high-class effluent is needed, and where the cost of producing it is not a matter to be considered.

CHAPTER XXXVII.

Sludge and its Disposal.

Whether the settlement of the solids in suspension in the crude sewage be effected in the settling tanks by chemical precipitation, aërobic bacteria in open, or anaërobic bacteria in closed septic tanks, quiescent or continuous flow sedimentation, the resultant "sludge" precipitated to the bottom of the tanks has to be removed after the effluent, or top water, has been run off.

In the course of all the above processes, a flocculent precipitate is formed, a part of the dissolved slimy organic matter is coagulated, and this slowly settles to the bottom of the tanks as "sludge." This word sludge, as has been well expressed, "commonly denotes a foul-smelling tenacious slurry, which will not dry readily, but ferments, and produces a stench of far-reaching character." It is its filthy character which is the chief cause of the difficulty experienced in its disposal. As regards the quantity of sludge produced, it is considered that an average domestic sewage will produce approximately 1 ton 11 cwt. of dry sludge per 1,000,000 gallons of crude sewage.

"Sludging" the Tanks.

The length of the intervals between each "sludging" depends upon the particular process employed in precipitating the solids to the bottom of the sedimentation tanks; the nature of the chemicals (if any); the nature of the crude sewage dealt with; the weather and temperature; and the tendency to choke. These intervals seldom vary more than a week.

Various means are employed in sludging. At Hendon, where the sewage from the high level district is, for the most part, a residential one, but contains some manufactories, which do not, however, affect the sewage, and a very large number of laundries, which send their wastes into the sewers, it is precipitated by alumino-ferric. At their works the tank to be sludged is cut off from use for the purpose, the effluent, or top water, is run off by means of a "floating" arm—at some installations "draw-off" valves (as Fig. 26) are used for releasing tank effluents—and the wet sludge is allowed to gravitate to a large sludge well, from which it is pumped into trenches cut in the land.

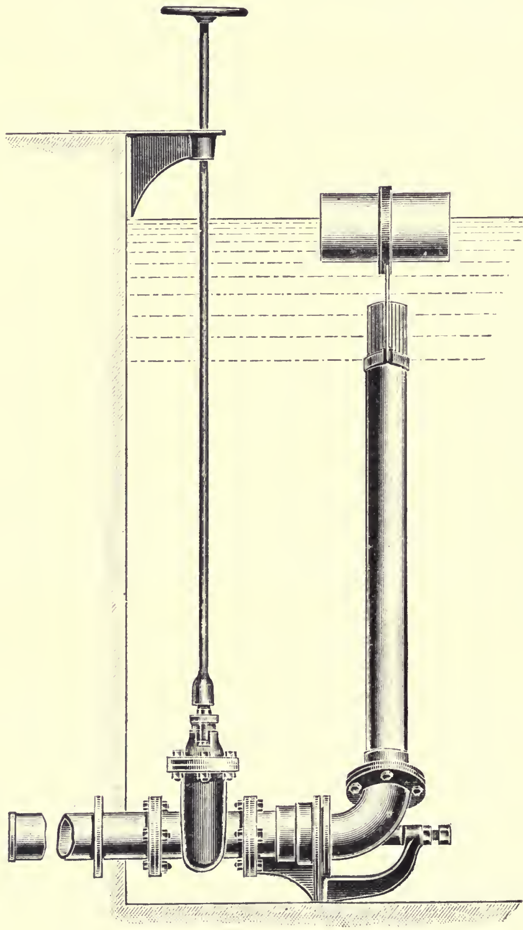


Fig. 26. "Draw-off" Valve.

In other cases it is forced out of the tanks by the "head" of liquid therein, and is controlled by means of the sludge valves (Fig. 27), fixed in the bottom of the tank, or leading from the side of it. Periodically these valves are opened, and the sludge forced into a sludge pit and there left to dry, or dug out and removed for "pressing,"* or carted away at once.

Fig. 28 shows a single-acting type diaphragm pump by Honig and Mock worked by hand lever, which is a type largely used for emptying sewage sludge tanks. It is constructed to discharge stones and pieces of bricks which have found their way into the tanks. This pump is also constructed to be worked by hand with fly-wheel and handle instead of lever.

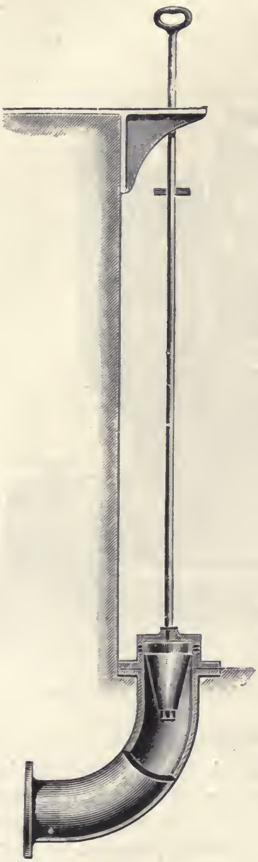


Fig. 27. Sludge Valve.

At Maidstone, where lime is used as the precipitant, the effluent is discharged from the tanks, and the semi-liquid, composed, as most sludges are, of something approaching 90 per cent. of water, is pumped out every other week.

At York, alumino-ferric and milk of lime are the chemical precipitants used, and one of the four tanks is cleaned out daily (Sundays excepted) by discharging the effluent through the floating arms, and then pumping the sludge to the pumps connected with the sludge pump.

At Calverley precipitation is brought about by the use of alumino-ferric, and the tanks are sludged every month, or second month, by running the sludge through the sludge valves into the sludge tanks, which are situated at the side of the precipitation tanks, after the effluent has been run off.

At Kingston-on-Thames a small Tangye's ram-pump (Fig. 39)† is used to pump the liquid sludge as often as necessary, from weekly to fortnightly, or more, into a large sludge well, whence it is sucked into an air-tight chamber, and from this it is forced by compressed air into the sludge presses.

* See p. 147. † See p. 180.

At works where the sludge is too solid and gritty to permit of its being forced through the sludge valves, it has to be cleared away by hand.

In every case the length of the intervals between the sludgings depends upon the weather and temperature.

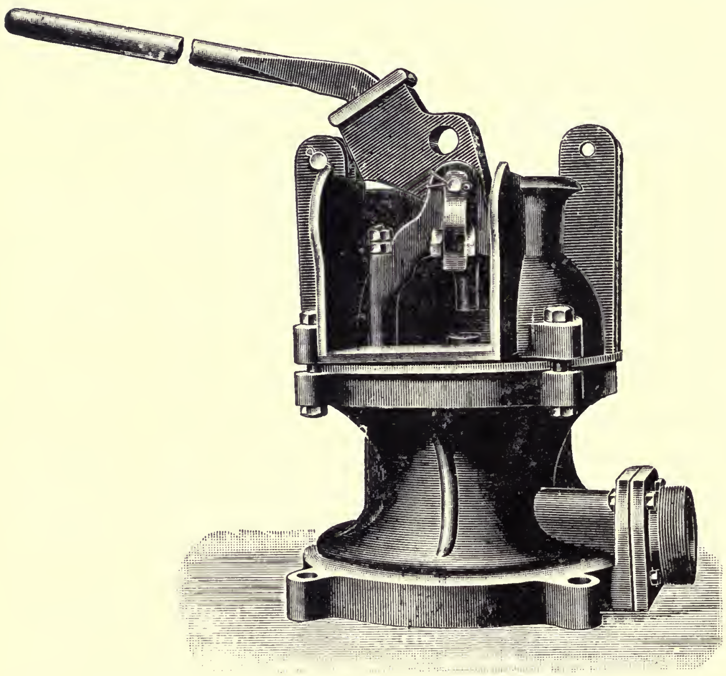


Fig. 28. Honig & Mock's Pump for Sludging.

Sludging and Cleansing Septic Tanks.

Theoretically, the longer the period of time which is allowed to elapse between the sludging of the tanks the better, because long intervals produce a less liquid sludge and less nuisance is also occasioned in the process. For example, a septic tank cleansed at the end of two years will produce a sludge containing approximately 80 to 85 per cent. of water, whereas if performed at the end of a few months this may amount to as much as 90 per cent. In practice, however, frequent partial removal of the sludge has been proved to be a desirable operation, in order to ensure constant conditions as regards the amount of the solids in suspension which issue from the tank with the effluent. The bacteria in the tank being unable to deal satisfactorily with the additional solid matter which a long interval between the cleansings tends to produce.

In order to prevent cessation in the fermentation, and digestion by the microbic action on the sludge, it is not considered advisable to remove the whole of it from the septic tanks. At the same time, the tanks should not be allowed to retain more than one-third their content of the sludge.

Disposal of Sludge.

One of the chief difficulties which presents itself in connection with the treatment of water-borne sewage artificially dealt with, is the disposal of the sludge deposited at the bottom of the precipitation or sedimentation tanks.

Burial of Sludge.

Where crude sewage is disposed of by land treatment, whether on sewage farms or otherwise, the wet sludge from the tanks is got rid of by shallow burial in adjacent land. In a few instances, as at Birmingham, Withington, Manchester, and Guildford, the sludge from chemically precipitated and septicised sewage is similarly dealt with.

To prevent the sludge becoming a nuisance, it is conveyed to the spot where it is to be buried, and as rapidly as possible dug or ploughed into the land. Lime may be added to deodorise it previous to its being carried to the land, especially if a strongly smelling sludge is being dealt with. Septic sludge not infrequently produces but little smell, unless the sewage contains large quantities of brewery or tannery wastes. During periods of snow and frost burial should not be attempted

The area of land required for the burial of sludge depends upon the nature of the former and the climatic conditions at the time of burial. In dry weather more can be got rid of on the same area of land than in wet weather.

With light, sandy loam and gravelly marl, 1000 tons of wet sludge can be dealt with per annum on half an acre of land. With stiff clay soil, from two to three acres are requisite.

The *cost* of burial varies somewhat, but from 5s. to 8s. per ton may be taken as an average.

Air Drying.

This is done in what are known as *lagoons or earth tanks*, constructed usually at the side or close to the sedimentation tank, by excavation and banking, with a drained bottom of clinker or some such suitable material, the size and the depth varying very much, usually 1 to 6 feet deep. The wet sludge is discharged into these lagoons, either by gravitation or pumping, to a depth of 1 to 2 feet. Here it is left to dry naturally for a varying period, depending upon the weather, mostly from two to six months. The process causes a good deal of smell, which is most objectionable in the vicinity of houses.

At Stratford-on-Avon the septic tank sludge is flushed out, and gravitates to the drying trenches through cast-iron pipes. The top water in due course is run off, and the more solid sludge is then covered with pulverised peat and dry slaked lime. The minimum of smell results from this method of treatment, to prevent or minimise which lime is sometimes added, as at Darwen.

When spadeable, it is dug out, and usually sold or given away to farmers, who use it for manure. The sludge then contains some 60 per cent. of moisture. The cost works out at about 1s. 2d. to 2s. per ton.

Burning.

Various attempts have been made in this direction, with but little success, especially with wet sludge, owing to the amount of moisture (some 90 per cent.) which it contains. House refuse, coal, resin, etc., is sometimes added before burning.

At Ealing the crude sewage is first automatically mixed in the precipitating tanks, which contain proportions of chalk and clay, the solids being, of course, then arrested in the tanks. Hydraulic pressure is then employed, with a view to removing as much moisture as possible from the sludge, which is pressed into cakes.

These cakes are then conveyed, by means of lifts, to the refuse destructor in which the town refuse is burnt, where they are burnt with it. The resultant hard clinker is crushed and mixed in a mill with Portland cement, the proportions being about one of cement to three of clinker.

This mixture is subsequently placed in moulds and subjected to a hydraulic pressure of about 2,500 lbs. per square inch. By this means a hard slab is produced, which is used for paving, at a cost, including laying, of about 3s. per superficial yard.

Some 2,500 to 3,000 tons are annually disposed of in this way.

At Ealing the sewage dealt with is one from almost entirely a residential district. The above method cannot be adopted with every class of sewage, as in some cases its composition causes the sludge to crumble when subjected to hydraulic pressure.

Pressing.

In this method the wet sludge is usually first run from the settling tanks into a sludge well, or tank, where it is mixed with milk of lime (about 5 grains per gallon) and allowed to settle. Septic-tank sludge requires the addition of twice as much lime as that resulting from chemical precipitation to prevent the press cloths from becoming clogged. Hence it is a much more expensive process. Where simple precipitation of crude sewage is employed, however, almost as much lime is required as for septic-tank sludge.

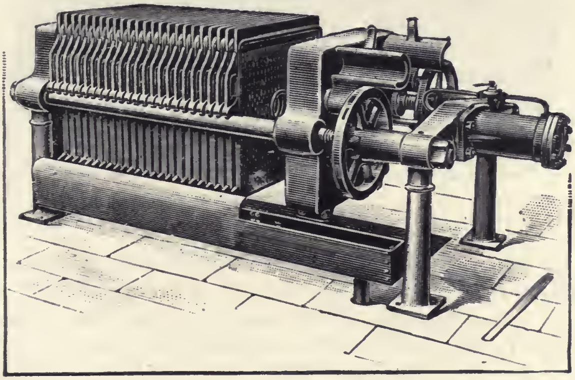


Fig. 29. Sludge Press.

Pressing the sludge from the tanks in a suitable filter press, worked by steam or hydraulic pressure, is one of the most satisfactory methods of eliminating a very large proportion of the 90 per cent. of moisture which it contains on leaving the tanks, and also preventing secondary decomposition setting in. By this process some 30 to 35 per cent. of the moisture is eliminated.

Fig. 29 illustrates a Manlove-Alliott filter press with thirty chambers. It is fitted with patent air cylinder for closing up press head and plates. The distance plates are shown lifted up, and the head moved back for emptying the pressed cakes into which the sludge has been converted. The press is fitted with vertical cast-iron plates (Fig. 29a), which serve to support cloths of canvas, felt, or hemp, which act as the filtering media.

The wet sludge is usually passed between these plates by sludge rams worked by compressed air, and the plates are tightened up. The filter cloths allow a great deal of the water to pass from the sludge, but hold the solids, after which the plates are loosened and the sewage cakes, formed by this process, drop into a truck or other receptacle placed underneath the press, and are ready to be carted away for sale as manure.

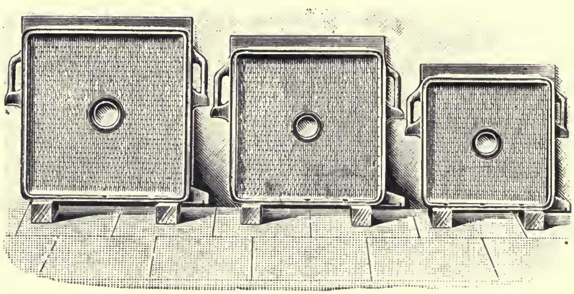


Fig. 29A. Square Sludge Press Plates.

The liquid thus pressed out should be pumped back into the tanks for re-treatment.

The pressed sludge itself does not give rise to serious nuisance from smell, and if exposed to the air in dry weather soon become inoffensive.

Much smell is, however, created in the press-house, which should therefore be properly ventilated. The total cost of the process varies from 2s. to 5s. per ton.

The pressed sludge cakes are usually got rid of to the farmers (see its manurial value, p. 151). Some pay a trifle, 6d. or 1s. per load; in other cases the same amount is paid to farmers to remove them.

At each operation a press of this size can produce about half a ton of cake.

Discharging into the Sea.

Where the disposal works are situated near the sea or on a canal or river, the cheapest way is to load the wet sludge, containing about 90 to 95 per cent. of moisture, directly it is dug out of the tanks into specially constructed barges, having a capacity of 100 to 200 cubic yards, and to convey it into deep water.

This method is adopted at London, Glasgow, Manchester, Salford, Dublin, and Southampton, at a cost varying from 4d. to 1s. 4d. per ton.

Conversion into Special Kinds of Manure.

In some cases sewage sludge is converted into special kinds of manure. It will suffice to describe briefly two processes, that followed at (a) Kingston-on-Thames, and (b) Dalmarnock (Glasgow):—

(a) Here the character of the sewage dealt with is domestic, with some brewery, tannery, and gas liquor refuse. It is treated by the "A.B.C." process, introduced many years since by Mr. Sillars, in which the crude sewage is precipitated by the addition of alumino-ferric, blood, charcoal, and clay (about 50 grains per gallon), an extremely efficient precipitant.

On its removal from the tanks, the sludge is pressed to remove as much as possible of the 90 per cent. of moisture still present therein, partially dried by heat and sieved, and, after further air drying during storage, is sold under the name of "Native Guano." In the pressed cake there is some 50 per cent. of moisture, and in the liquid about 75 per cent.

This manure is largely used for flower culture.

(b) In this case the sewage dealt with is domestic and manufacturing.

It is precipitated with lime and ferric sulphate, pressed artificially, dried at a temperature of about 65 to 70 degrees centigrade, and, lastly, passed through a pan-mill, from which it issues in a brown powder.

It is called "Globe Fertiliser," which finds a ready and increasing sale to farmers.

Results.

Unless applied in large quantities, sewage sludge is not a suitable dressing for quickly-growing plants. It has undoubtedly manurial value, but, from the standpoint of economic use, although it can be obtained for a trifle at sewage treatment installations, all will depend upon the cost of carriage, because the manurial constituents, even although the crude water-borne sewage is previously screened in detritus tanks, are mixed with a large proportion of grit, etc.

CHAPTER XXXVIII.

The Manurial Value of " Sludge."*

Experiments with Roots, Hay, and Wheat.

" The fundamental agricultural question is, and will remain, the manurial question." Such was the opinion of the eminent French scientist, Jean Dumas, more than fifty years ago, and the investigations of the intervening years have confirmed his views. Within recent years it has come to be accepted that biological processes have a definite relation to soil fertility; and now, from Government experiments in the United States, it would seem that manure is one of the most powerful agents commonly available on the farm which, with proper handling, can be used for promoting or controlling the activity of the bacteria of the soil.

Human Excreta as Manure.

The reasons for the use of human excretal matter as manure may thus be briefly summed up: That the fæces, are the wastes given off after the body has derived its nutrition from the vegetable or animal food of which it has partaken; that the former comes direct from the land, and the latter has derived its nourishment from it; therefore, to fulfil the ordinary " cycle of events," that which comes off the land should in due course be replaced.

It was suggested at one time that the use of such matter for manurial purposes might be a source of danger to persons and animals partaking of products grown on land to which it had been applied and causing some to become injuriously affected by some pathological process. This theory may now be considered an exploded one, and the possibility of anthrax spores, for instance, being contained in sewage sludge is also very remote.

What is Sludge?

In most towns, and in many large villages also, the sewage matter, consisting of the human fæces, house waste waters, liquid wastes from stabling, street washings, manufacturing

* This subject is somewhat fully dealt with for the benefit of country readers, and others interested in agricultural matters.

and brewery wastes, etc., is admitted to a sewerage system, by means of which it is carried in pipes to an installation for "treatment" and disposal. Here, as a preliminary part of the treatment, settlement of the solids in suspension in the crude sewage has to be effected. To ensure this, the sewage is received into specially-constructed chambers, or "tanks" as they are called, where either chemical precipitation, quiescent or continuous flow sedimentation, or septic tank is employed. In the first the chemicals, most used are alumino-ferric (a trade name for a chemical precipitant), lime, ferric sulphate, or alum. In quiescent settlement the sewage remains in the tanks for two or three hours, which permits the solids present to settle to the bottom. In continuous flow settlement the crude sewage passes very slowly but continuously through the tanks for the same purpose. With septic tanks the precipitation of the solids is left to bacterial action, the sewage being left eight to twelve hours in the tank.

To the solid matter which thus forms on the bottom of these sedimentation tanks has been given the name "sludge." The top water, or "effluent," is passed off at the expiration of the proper intervals, and a fresh lot of crude sewage is admitted. The sludge is only removed periodically—depending on the nature of the sewage and whether the precipitation has been effected by antiseptic or septic methods (e.g., by the addition of chemicals or bacterial action), or otherwise—possibly three or four times a year. The sludge, after undergoing certain processes, including "pressing" into cakes by special machinery, in which a good deal of moisture is extracted, is *disposed of to agriculturists* for manure. In some special processes it is converted into such composts as "Native Guano" and "Globe Fertiliser," for sale in bulk or in bags.

Agriculturists whose land is situated within a reasonable distance of any town sewage treatment installation can usually secure pressed cakes of sludge for a few pence per ton, and the cost of carting sometimes free. Such specially-prepared marketable manures as those above mentioned are sold for 8s. to 14s. per ton, purchaser paying carriage.

To produce "Native Guano," the sludge resulting from the precipitation of crude town sewage by the addition of alumino-ferric, together with blood, charcoal, and clay, on removal from the tanks, is "pressed," then partially dried by heat and sieved, and further air-dried during storage. It appears to be much used for flower culture.

This is one of the sludge manures used in the experiments with which we shall now deal, as was also "Globe Fertiliser," produced from sludge precipitated by the addition of lime and ferric-sulphate, which is first pressed and artificially dried, then passed through a pan-mill, from which it issues as a moist brown powder.

Opinions and Experiments.

At the present time opinions in regard to the manurial value of sewage sludge are of a very conflicting character, and we have recently had this fact authoritatively announced. Perhaps the ultimate outcome of experiments now being made will be the settlement of some important questions now outstanding.

These experiments, commenced in 1905, are being conducted on behalf of the Royal Commission on Sewage Disposal, through the Board of Agriculture and the Royal Agricultural Society, at several collegiate centres, and take the form of three series:—Series I., with *mangolds, swedes, and turnips*, under the direction of Dr. W. Somerville; Series II., with *hay*, under the direction of Professor Middleton and Dr. Voelcker; Series III., pot culture experiments with *wheat*, also by Dr. Voelcker. So far, these investigations have been carried out at the following centres, and the details set out in Table XIII. have been taken from two tables given in the report on the subject issued by the Royal Commission:—

TABLE XIII.

Agricultural Experiments with Sludge.
Some Details as to Situation, Nature of Land, &c.

Place.		Nature of Soil.	Condition of Meadow Land.
Rothamsted, Herts.	(a)	Strong flinty loam overlying chalk	
,, ,,	(d)	Heavy clay loam	Old meadow land
Cambridge University (Agricultural Dept.)	(a)	Moderate gritty loam overlying gault	
Leeds University (Agricultural Dept.)	(b)	Strong drift soil overlying the clay measures	
Ditto	(b)	Medium loam	Old meadow land
South-Eastern Agricultural College, Wye, Kent	(b)	Strong flint loam overlying chalk	
Ditto	(d)	Somewhat stiff loam overlying chalk	Pasture of some years' standing
Glasgow and West of Scotland Agricultural College	(c)	Strong loam on the carboniferous formation	
Ditto	(d)	Heavy clay	Grass in its first year.
Also, with hay only.			
North of Scotland College of Agriculture, Aberdeen.		Poor wet clay	Field had been in grass for six or eleven years, but was in extremely poor condition.
Armstrong College, Newcastle-on-Tyne		Clay loam	Field had been in grass for about thirty years.
University College of North Wales, Bangor		Gravelly soil	Old meadow land

(a) Mangolds, (b) swedes, (c) turnips, (d) hay.

Seven different sludges were used in each of the three series of experiments, derived as follows:—(1) "Native Guano" (previously described); (2) sludge precipitated by the addition of lime (10 grains) and alumino-ferric (5 grains) per gallon of sewage; (3) alumino-ferric precipitation sludge; (4) sludge precipitated by the addition of calcium phosphate and lime (4 and 1 grain respectively to the gallon of sewage); (5) sludge from septic tank; (6) "settled" sewage sludge (no chemicals used); (7) "Globe Fertiliser" (previously dealt with).

In Series I.:—*Experiments with turnips, mangolds, and swedes.* Twenty-two plots of land in duplicate, each one-twentieth acre, were selected, on which it was decided to use such quantities of each of the sludges as would supply, as near as possible, 40 lbs. of nitrogen and 36 lbs. of phosphoric acid per acre, because of the inability of each to supply equal quantities of the manurial constituents. With sludge No. 1, 2,072 lbs. supplied this amount. On the first seven duplicate plots each received an amount of one of the sludges equal to 2,072 lbs. per acre. Twelve other duplicate plots were used for comparative experiments with No. 1 sludge, mixed with either sulphate of ammonia, superphosphate, or both; and also for experiments with sulphate of ammonia, superphosphates, and fish meal, either together or alone. The whole of the experimental plots received an equal dressing of potash salt, supplying 30 lbs. of potash per acre. "The season of 1905 was somewhat abnormal in character, and, on the whole, not very favourable to the action of manures," reads the report; and, comparing the results obtained with sludge No. 1 alone and mixed with either superphosphate or sulphate of ammonia, Dr. Somerville shows:—"(1) That the *phosphate of the sludge* is less active than the phosphate in the superphosphate, because the addition of a further quantity of phosphoric acid in the form of superphosphate produced a greater relative effect in the former than in the latter. (2) That there are similar indications with regard to the *nitrogen of the sludge.*" "From the direct comparison of the effects of equal weights of nitrogen (20 lbs. and 40 lbs. respectively) and phosphoric acid (18 lbs. and 36 lbs.) derived from sludge No. 1, and from sulphate of ammonia with superphosphate and with fish meal," the report shows "that the sludge-grown crop is in nearly every case considerably inferior in weight to the crop grown with artificial manure."

His conclusion is: That no consistent manurial effect was produced by the sludges on the root crops grown in the experiments—mangolds, swedes, and turnips—in the 1905 season, which was of a character which militated against the growth of such crops, though allowing artificial manures to "exert a considerable influence on the growth of this crop."

These experiments are, however, being continued, as it is thought that sludge may be slow acting as a manure, and therefore further experimenting may produce results of considerable importance.

Series II. comprised experiments with sewage sludge upon *hay* at the centres shown in the above Table, and also on *grass land* at Woburn. They were similar to those of Series I.

At the Northern experimental centres, the wet summer was favourable to slow-acting manures, and the application of the sludges seems to have been useful. In the Southern counties, where the hay is, of course, cut much earlier, the sludges produced no results whatever.

Comparing the action of the nitrogen and phosphates supplied in the ordinary artificial manures with those chemicals present in sewage sludge, it would appear that for root crops and grass the action of the latter is very slow, so that it seems very likely "sludge supplied in proper quantities would form a good dressing for the slow-growing plants of many permanent pastures and meadows." Sludges precipitated by the addition of lime to the crude sewage seem to be more valuable as manures than those resulting from precipitation with salts of alumina or iron. This is only, perhaps, to be expected bearing in mind phosphate of lime is more readily assimilated by plants than phosphate of iron or alumina. The above experiments are being continued, as before, under the direction of Mr. Middleton. Others were carried out on similar lines by Dr. J. A. Voelcker, at Woburn. Eleven plots of one-fortieth acre were employed, seven of which were dressed with each of the seven sludges set out above in quantities sufficient to supply 40 lbs. of nitrogen per acre. The soil of the field, which is on the junction of the Lower Greensand with the Oxford clay, partakes of the character of both formations. The grass was only moderate in quality. One of the plots was left unmanured; the other three also received a dressing of lime.

"In all experiments conducted on grass land, it is unfair, and often misleading," says Dr. Voelcker, "to take the results of a single year as conclusive." The dryness and absence of warmth which characterised the season of 1907 militated against satisfactory experiments. Here, again, it would seem that their continuation is called for, because it is considered in every way likely that the sludges require a longer time to show their influences.

Series III. consisted of experiments with *wheat* culture in pots holding 40 and 32 lbs. of soil, the last fifth of which was in each case incorporated with the sludge or artificial manure. The same seven sludges were used.

The experiments were divided into three groups:—

(1) A comparison of the manurial effect, on the wheat crop, of one kind of sewage sludge as against another, when these were respectively applied in quantities calculated to supply 40 lbs. of nitrogen per acre.

(2) A comparison of the effect of each individual sludge with that of an artificial dressing composed of superphosphate, rape dust, and lime, calculated to supply the same amounts of phosphoric acid, nitrogen, and lime as did the corresponding sludge.

(3) A comparison of the cost of increase of crop, obtained by the addition of sludge and by artificial manures of known cost. In this experiment the sludges were used in equal weights (two tons per acre), and compared with dressings of artificial manures such as a farmer would be likely to use.

On comparing the rootlets of the plants four months after planting (in April, 1907) but little difference was shown from the various sludges; on the other hand, the artificials had in each case given the larger and stronger root growth. In the end sludge No. 2 (see above) showed the best results of the sludges.

Dr. Voelcker arrives at the following conclusions:—

"(1) That the different sewage sludges, when used in sufficient quantity to supply 40 lbs. of nitrogen per acre, are capable of increasing the yield by 10 to 12 per cent. above the unmanured produce.

"(2) That artificial equivalents of the different sewage sludges will similarly give 16 to 17 per cent.

"(3) Sewage sludges mostly produce greater length of straw.

"(4) Those sludges which contain the most moisture and lime do the best among them. For wheat-growing none would be worth 10s. per ton on the farm.

"(5) That the value of the sludge does not turn mainly upon the amount of nitrogenous organic matters contained, but that these may indeed be in a form incapable of ready assimilation and requiring lime for their decomposition."

From the total results of the experiments so far conducted, the Commissioners conclude *that sewage sludge has undoubtedly a manurial value,* but the manurial constituents, being of necessity mixed with such a large proportion of grit, etc., the question of its economic use as a manure depends, to a large extent, upon the cost of carriage.

The results of the extended experiments will be awaited with much interest. In the meantime the experiences of individual agriculturists would doubtless make welcomed additions to these official experiments if they were conducted upon scientific lines, and based upon analyses of the sludges used.

CHAPTER XXXIX.

Automatic and other Appliances.

In works connected with the treatment and disposal of sewage by any satisfactory method, and whether on a large or small scale, the employment of various mechanical appliances is a necessity. Briefly, they are required for controlling and measuring the flow, admitting and releasing it from tanks and "beds," "lifting" it in cases where it is not possible to rely on gravitation, and distributing the sewage on to filter beds, etc.; the ventilation and flushing of the sewerage system must also be a factor for consideration, and calls for the employment of some mechanical means.

The Value of Automatic Gear.

There seems no question but that the employment of skilled supervision of the various appliances used in sewage treatment is to be preferred to mechanical means. In large works this can always be ensured. There is no doubt but that automatic appliances save a large amount of labour in regulating the filling and emptying of tanks, contact beds, and filters; but, at the same time, it is not desirable to rely entirely upon such apparatus, owing, chiefly, to their liability to get out of order.

In the case of smaller works, especially those of a private character, cost of maintenance is a feature which must always be considered, and consequently the retention of a capable man cannot always be ensured on account of the outlay which it necessitates. Automatic appliances have therefore to be relied upon; though occasional attention at least is then necessary. If this can be given daily, so much the better.*

Measuring Appliances.

It is essential in so many cases to have an accurate knowledge of quantities under various conditions, that a satisfactory measuring meter is an essential feature in properly-planned sewage installations. Among the uses of such an appliance may be mentioned the ascertainment of

* A magnifying glass will be found useful in studying most of the illustrations in this book.

the exact quantity of chemical precipitant to be used for sedimentation purposes, and for measuring the requisite quantity to be added of lime, alumino-ferric, sulphate of alumina, or other chemical precipitant. Another useful purpose is the ascertainment of the volume of sewage pass-

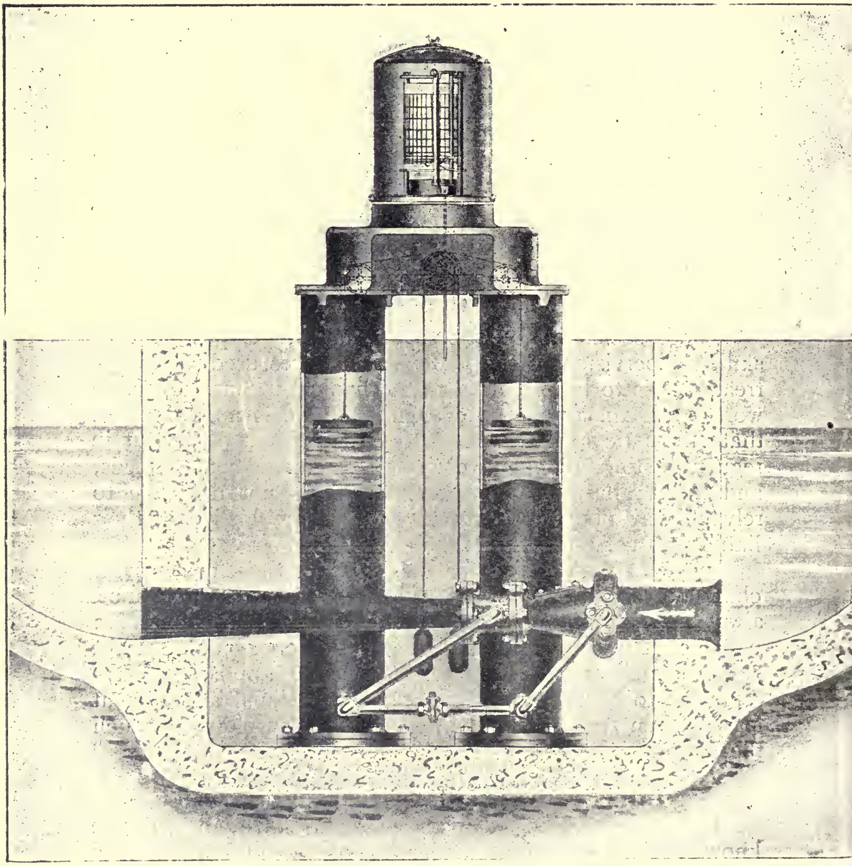


Fig. 30. Kent's "Venturi" Meter.

ing into the settling tank in any given period for the purpose of fixing the amount of such precipitant to be added for that purpose; also for the measurement of the total volume of sewage flowing to the works.

Kent's Meter.

This Meter (Fig. 30) consists of two parts—the tube and the recorder. The latter is designed to register and record the quantity of sewage passing it at every hour of the day by means of two water columns, by the aid of which any variations in the level of the water are conveyed to the recording mechanism. The record is indicated on a chart, which shows change in rate of flow in gallons, cubic feet, or lbs.

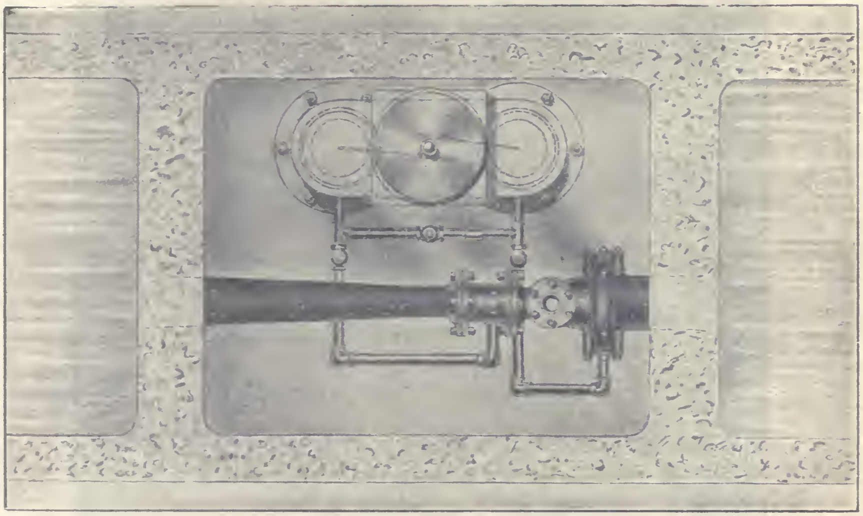


Fig. 30a. Kent's "Venturi" Meter.

Jennings' Automatic Recording Gauge.

The apparatus (Fig. 31) is constructed to show the rate of flow of effluent to the filter beds and to record the daily and hourly fluctuations. A pen, actuated by the height of liquid on a weir, indicates this.

Regulating the Flow.

The flow of sewage may be controlled in various ways, depending, as in all other cases, on the quantity to be dealt with and the purposes for which used. In some instances automatic appliances may be considered as likely to satisfy the demand.

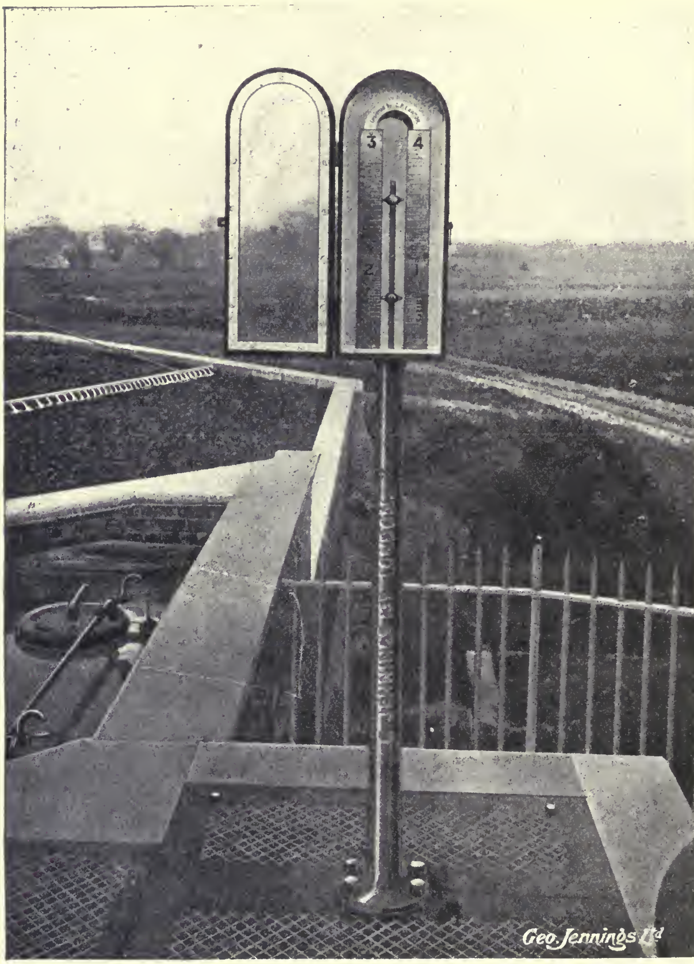


Fig. 31. Gauging Apparatus.

Valves are not infrequently used to control the flow, especially with smaller sewerage pipes. Where large sewers are concerned, Penstocks are employed (Fig. 47).* "Flushing gates" are commonly used where sewers can

* See p. 192.

only be laid with a very trifling gradient, for the purpose of "holding up" the flow and discharging same when the desired quantity has been held back. The process is sometimes employed in conjunction with automatic syphons.

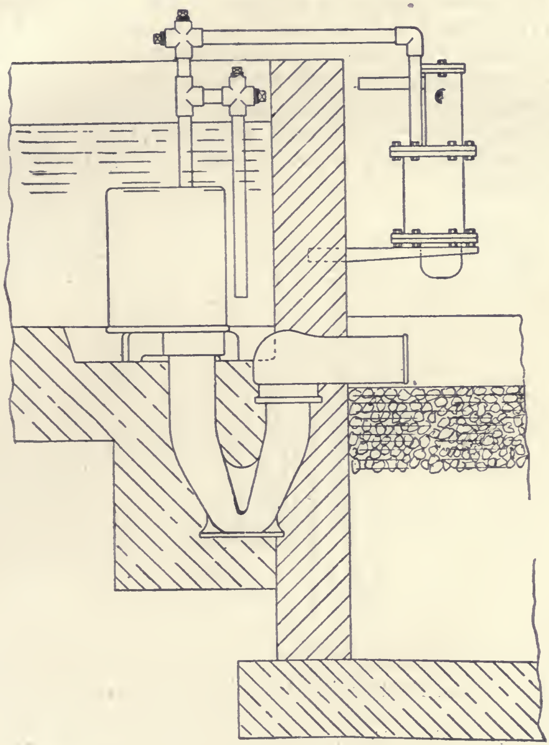


Fig. 32. Burn Brothers' "Sequela" Alternating Syphon.

Burn Brothers' Automatic Apparatus for Controlling the Filling and Discharging of Tanks or Contact Beds.

"SEQUELA" ALTERNATING SYPHON; "HOROMETER" TIMING SYPHON.

Primary contact beds are usually supplied with sewage from a collecting or dosing chamber, in which two or more discharge syphons are fixed, or they may be filled from a supply channel under certain circumstances. In the former case, a syphon discharges immediately the collecting chamber is full.

The "Sequela" Alternating Syphon (Figs. 32 and 33) is employed for automatically delivering sewage to settling tanks or contact beds in rotation. The relief apparatus (Fig 33) is divided into three compartments, and depends for its working on the transference of oil, of a special nature, from one compartment D to another compartment B viâ compartment F in stages, corresponding with the number of syphons under control, each relief apparatus at the commencement being set a stage in advance of the one next to

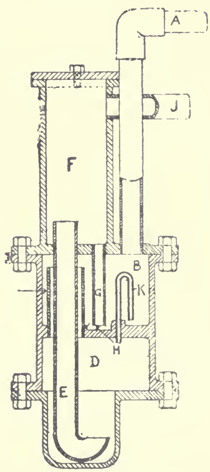


Fig. 33. Burn Brothers' Patent Sequela. Enlarged View.

it. After a syphon has discharged, the oil which has been transferred to the compartment B in the relief apparatus is automatically returned to the compartment D, and the apparatus is then ready for another series of operations. Thus, the oil is used over and over again, and as it does not come in contact with the sewage, it remains quite pure and serviceable for years.

"Horometer" Timing Syphon.

A discharge syphon (Figs. 34 and 34a) is fixed in each bed, and in order to ensure a proper period of "contact" of the sewage with the filtering material, each syphon is provided in this method with a "Horometer" relief apparatus. This apparatus can be set to give a period of "contact" varying from twenty minutes to twenty-four hours.

The "Horometer," like the "Sequela," depends upon the transference of oil from one compartment to another,

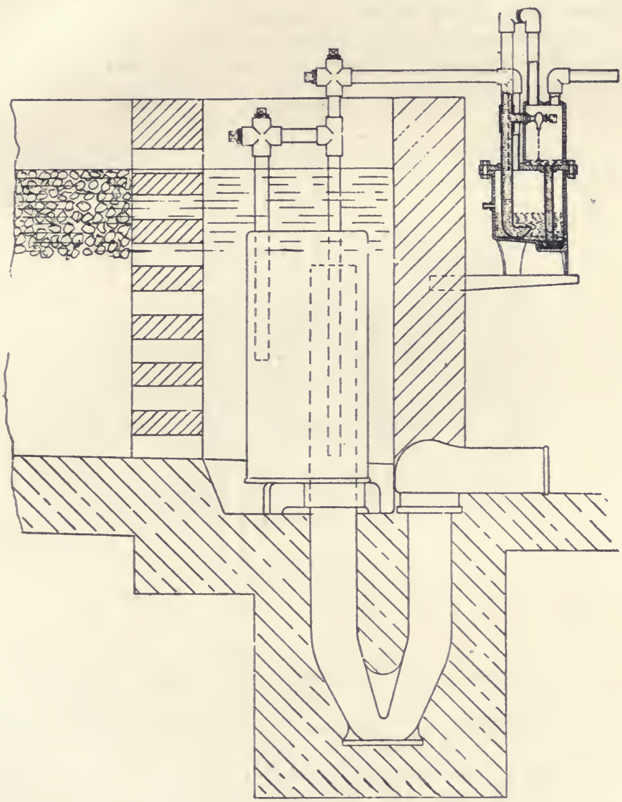


Fig. 34. Burn Brothers' "Horometer" Timing Syphon.

but in this case only two compartments are necessary, M and P.

As the filter fills the oil is forced by air pressure to rise in a vertical pipe, from compartment M above the level of a regulating tap, which is set to pass the oil into compartment P in the time determined upon for the "contact" of the sewage in the bed, and as soon as the necessary quantity of oil has been transferred through the tap the automatic discharge of the syphon takes place, and the effluent is withdrawn from the bed.

After the syphon has discharged the oil is automatically returned from compartment P to compartment M, and the apparatus is again ready for use.

No water-tight brick chambers or compartments are required in the contact beds in connection with the appara-

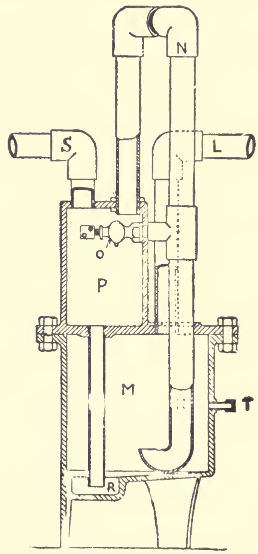


Fig. 34A. Patent "Horometer." Enlarged View.

tus. It is only necessary to construct a screen in dry brickwork or perforated iron around the syphons to hold up the filtering material (as Fig. 35).

Figs. 36 and 36a illustrate the application of such apparatus to two series of primary and secondary beds and sand filter. The sewage enters a grit or detritus tank B, from which is passes by way of the dip pipe C into the variously-styled liquifying or resolving or other kind of septic or sedimentation or chemical precipitation tank D, from whence it passes through the outlet dip pipes E, into a collecting or dosing tank F, from which, after the requisite quantity of tank effluent has been collected, its contents are discharged in rotation, through one or other of the three "Sequela" alternating syphons G, into the primary contact beds H. Here the effluent is held up by the "Horometer" timing syphon J for the required period of "contact," and at its expiration this syphon releases the effluent from the primary bed, and similarly on to the secondary beds K, and so by way of the "timing" syphon at L, through the channel O, to the outlet P.

Automatic "Cut-out" Valves.

Messrs. Hodgson and Walker's patent is illustrated at Figs. 37 and 37a, and is useful in times of storm for cutting

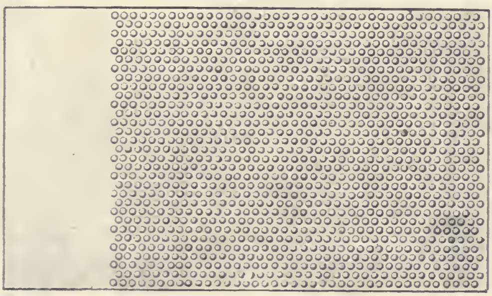


Fig. 35 Burn Brothers' Perforated Strainer for "Holding up" the Filtering Medium in Bacterial Filters. Flat or Curved.

off the flow of sewage to the tanks in greater quantities than is required because the excessive dilution of the water-carried sewage necessarily affects the putrefactive powers of the bacteria, and by thus causing the effluent to be less pure throws more work on the contact beds or filters than they can satisfactorily perform, and as a consequence they cannot produce an effluent of the quality usual when treating a dry-weather flow tank effluent. By the use of this valve a greater flow of sewage than, say, three and a-half times the normal flow, is diverted from the septic or sedimentation tank (if such be employed), after leaving the detritus tank, owing to the floats (FF) lifting suddenly and reversing the valves, thus diverting the flow on to the storm-water filter.

Automatic Pneumatic Ejectors.

Wherever possible gravitation systems of sewerage should be arranged. But not infrequently it is impossible to do

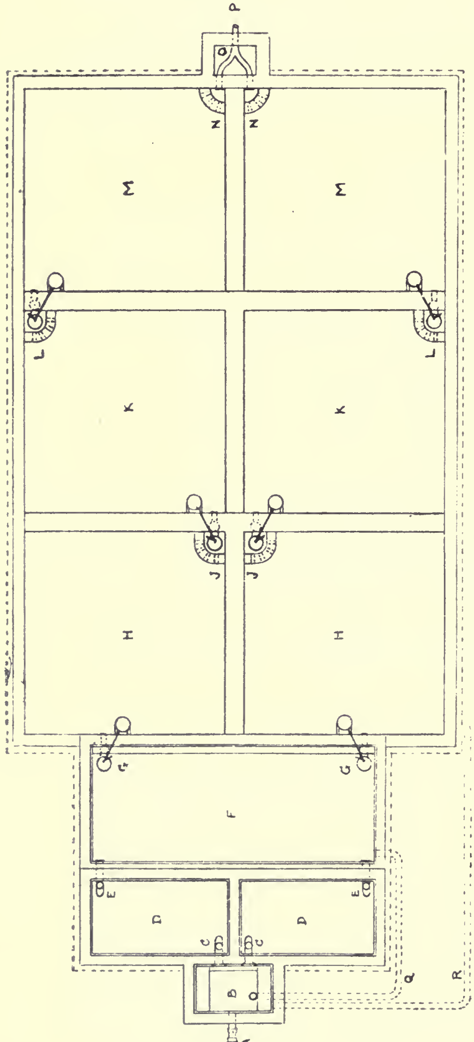


Fig. 36. Plan of Sewage Purification Works, showing Burn Brothers' "Sequela" and "Horometer" Syphon applied.

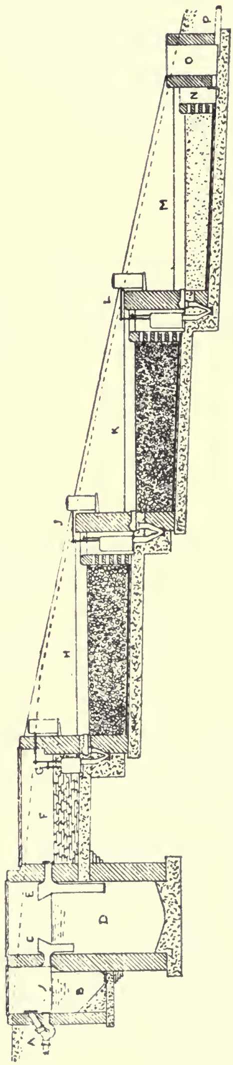


Fig. 36A. Section of Ditto, showing Application of such Syphons.

this, because of the difference in ground level, and consequently some other methods have to be devised. In most cases pumping has to be resorted to to raise the sewage to the higher level. This is, in most instances, an expensive process, and is to be avoided where possible.

Where the difference in level is slight, to raise sewage from a lower level, automatic pneumatic ejectors may be

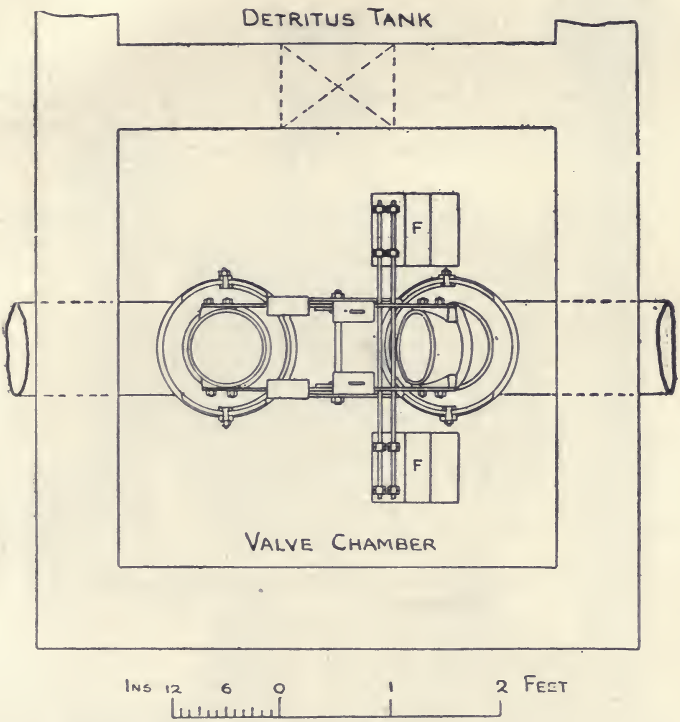


Fig. 37. Plan of Automatic "Cut-out" Valve.

usefully employed. They should be fixed at such a level as to enable their being filled by gravitation. An ejector, in its simplest form, should consist of a chamber into which the sewage flows by gravity, and in which it is "held up." Inlet and outlet valves are, of course, essential, as well as a mechanical contrivance for automatically admitting the air under the pressure required for "lifting" the sewage when the chamber is full, and causing it to be discharged through the delivery valve.

It is preferable for the ejectors to be fixed in pairs to admit of the flow of sewage being continuous.

Ejectors may be used with sludge pressing machinery for forcing the sludge into the presses.

The Shone Pneumatic Ejector.

This is employed for lifting sewage where the district to be sewered is low-lying and self-cleansing gradients cannot be ensured throughout. Any number may be operated from one central station by means of compressed air.

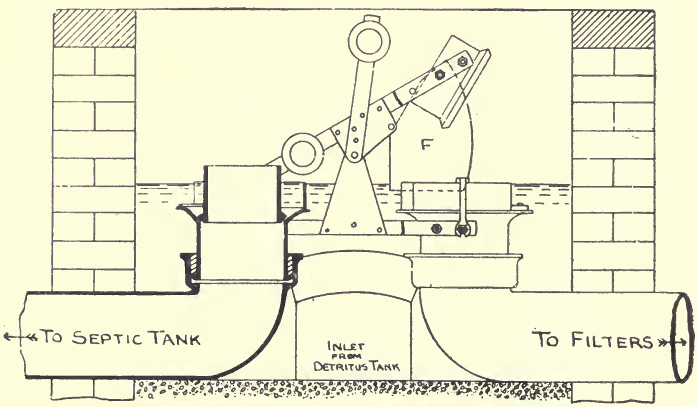


Fig. 37A. Section of Automatic "Cut Out" Valve.

Fig. 37b illustrates a sectional view of the Shone ejector for lifting sewage, sludge, etc. The sewage enters it at A by gravitation, and rises therein to D, where there is a "bell" with air at atmospheric pressure compressed by the rising sewage, which passes out at B. The weight of the cup C, when the fluid has passed out of the ejector causes the compressed air admission valve E to fall, and the ejector is ready for re-charging.

The power for the compressed air may be electricity, steam, water power, or gas or oil engine, and refuse destructors may be utilized if available.

Where the ejectors are placed in pairs, each may operate independently, and one may be shut down for examination while the other continues to perform the work; or the ejectors may be arranged to work alternately with one another, giving a steady and continuous flow of sewage. The com-

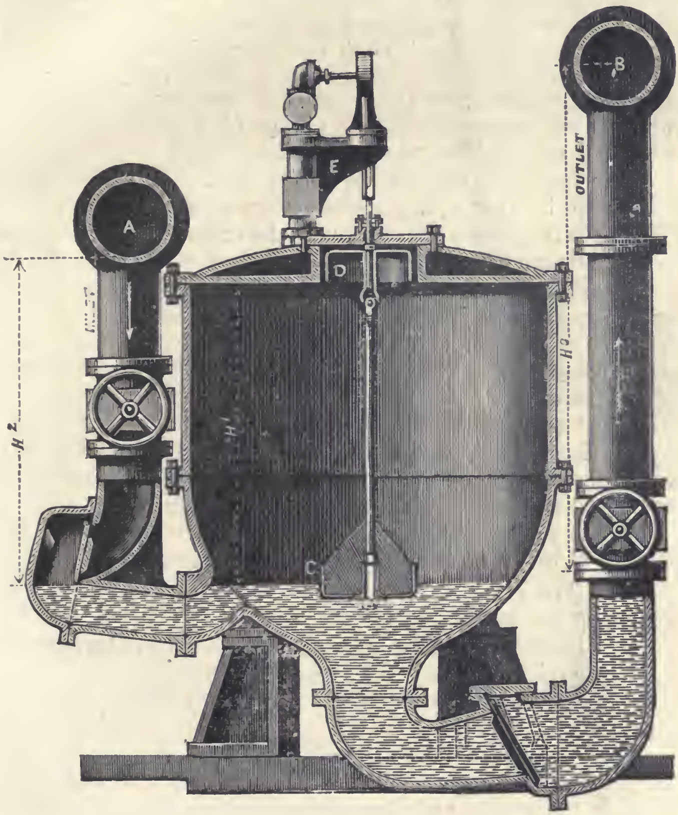


Fig. 37B. Section of "Shone" Ejector.

pressed air for actuating the ejectors can be produced at some central station and conveyed in cast-iron spigot and socket pipes, having joints caulked with yarn and lead; these can be laid under the streets to the several ejector stations.

The "Coombs" Pneumatic Ejectors.

The "Coombs" Pneumatic Ejectors, made by Messrs Daniel Adamson and Co., of Dukinfield, have several distinctive features. The three most prominent are:—

(1) The increasing of the efficiency of the ejectors by recompressing the exhaust. Though many attempts have been made to use the compressed air expansively in pneumatic ejectors, the "Coombs" High Efficiency Ejector is one of the first to do so in a simple, effective and reliable way. Messrs. Daniel Adamson and Co. have had such an arrangement working for six months in the charge of a simple roadman, who had no previous mechanical knowledge.

The increased efficiency is 50 per cent., with an air pressure of 40 lbs. per square inch above atmosphere.

The arrangement is as simple as the ordinary ejector, it has all its advantages with its greatly increased efficiency.

A pair of ejectors are used, and these work alternately with one automatic air valve common to the two. At the moment of reversal both ejectors are directly connected, thus doing away with the trouble found in previous arrangements.

The arrangement is such that the ejectors must completely fill and empty, giving a maximum volumetric efficiency.

Having a closed circuit no foul air is discharged into the atmosphere, yet, as about 10 per cent. of fresh air is sucked in every cycle, the air has no chance of getting foul.

These ejectors can, if required, be placed above ground instead of below sewer, as is necessary with ordinary ejectors.

(2) There are several points which must be observed in designing ejectors.

The bodies should be as large as possible to reduce clearance to a minimum.

They should be as shallow as possible to reduce the drop as much as possible.

They should be deep, so that the acceleration of the discharge should be quick, so that the first rush should carry forward the solids, and thus prevent silting up of the rising mains.

The last two points conflict, and thus experience is required in deciding the depth of the ejectors. For the same reason the ejectors made by experienced makers are all of vertical type, though horizontal cylinders are cheaper. A further reason against the horizontal type is the fact that solid deposits always occur, and make frequent cleaning out necessary.

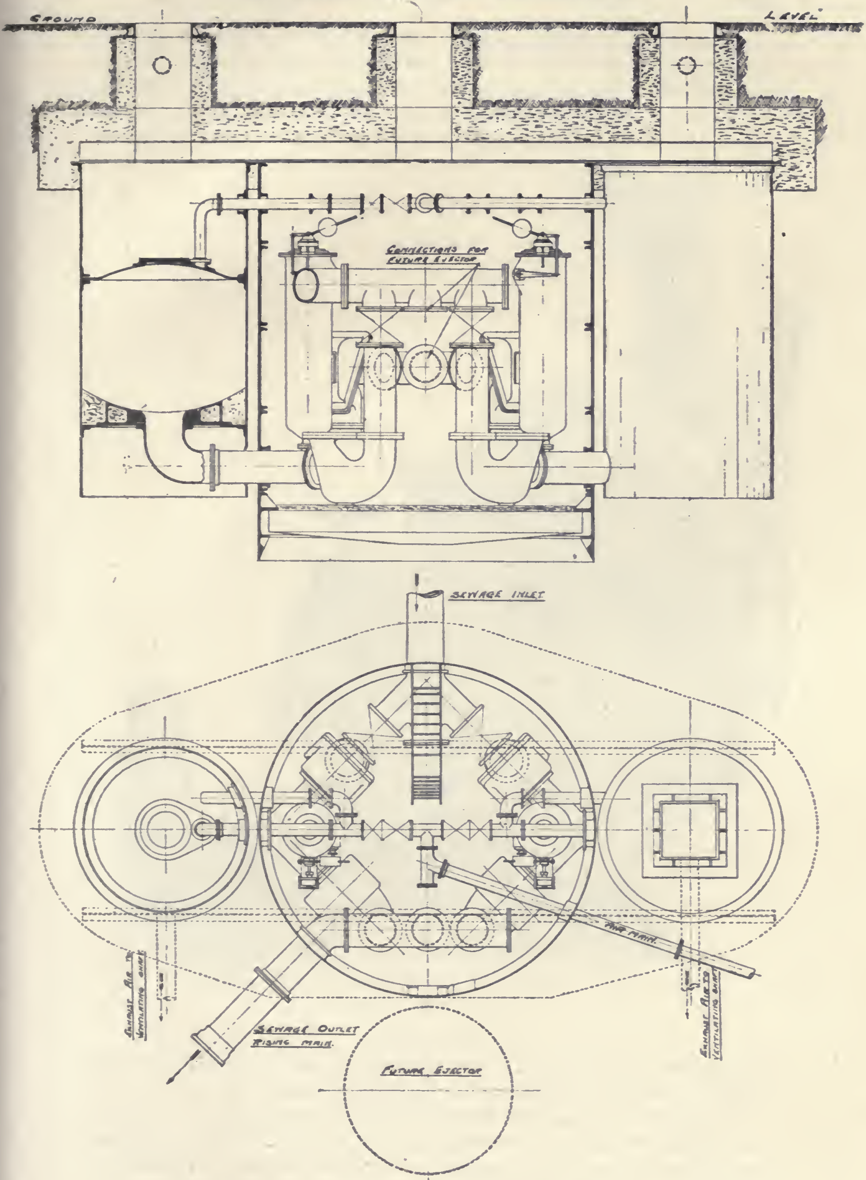


Fig. 37c. "Coombs" Pneumatic Ejector.

The complete filling and emptying of ejector bodies to ensure volumetric efficiency is also very important, and this is made absolutely certain by the adoption of the pilot ejector.

Due to the intermittent action of ejectors, solids drop when the flow ceases, and it is important the the ejectors

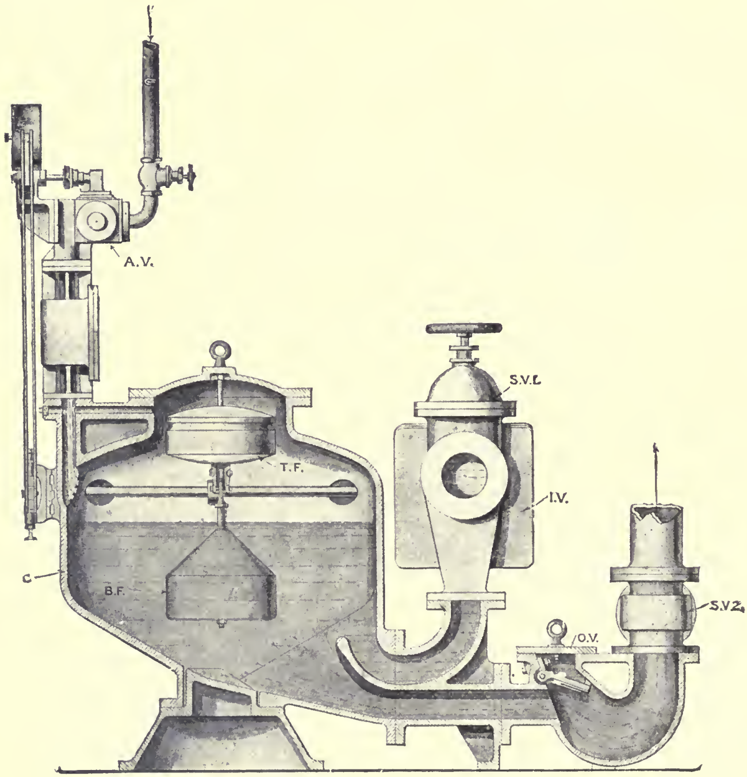


Fig. 37D. Sectional Elevation of a "Coombs" Pneumatic Ejector.

should be so arranged that the solids should drop where they must be carried forward at the next discharge.

Silence of exhaust is another important point.

If the "Coombs" design (Fig. 37C) is studied, it will be seen that all the above points have been carefully considered. Although the bodies of the ejectors are arranged outside the main chamber, yet all the valves and parts requiring attention are arranged inside it, and in such a way that a very large standing space is arranged in the centre of the chamber for the manipulation and inspection of working parts.

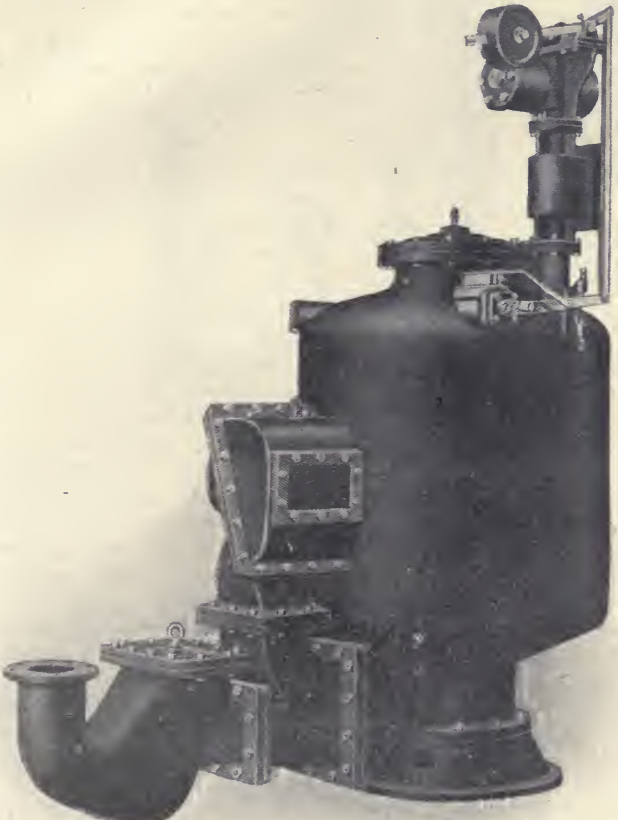


Fig. 37E. "Coombs" Pneumatic Ejector.

Very large exhaust chambers are arranged over bodies of ejectors, thus entirely silencing the exhaust.

(3) The "Coombs" arrangement for dealing with the night flow is a third important improvement. With this it is possible to store sufficient air to deal with this flow without

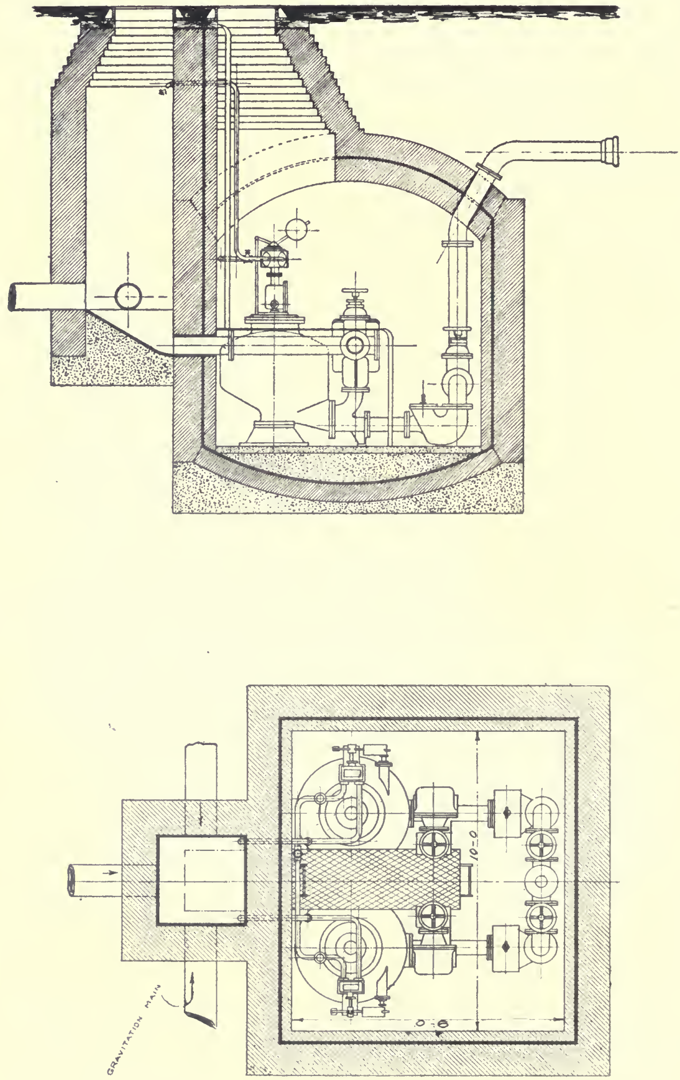


Fig. 37F. Two "Coombs" Ejectors in Brick Chamber.

having to run the air compressors at night. Though a high pressure is adopted for storage, the compressors only work during the day at the normal pressure required, except when storing of air is taking place at the end of the day. In the latest "Coombs" arrangement this is carried out automatically, thus reducing to a minimum the attention required.

Fig. 37d shows a section, Fig. 37e an elevation, and Fig. 37f a general arrangement adopted with the "Coombs" type of ejectors by Messrs. Daniel Adamson on their smaller sizes of ejectors.

Amongst other features which make these ejectors more positive and efficient may be mentioned their self-cleansing strainer and flap-valves, their equilibrium positive action valve gear and their latest types of automatic valves.

The Pulsometer Steam Pump.

This pump is useful in sewage treatment installations for pumping sludge. The action of the pump consists of two operations alternately performed, one being the emptying of the chambers by the pressure of steam, and the other the filling of the chambers by the subsequent condensation of the same. The control of these alternations is automatically performed by the oscillation of the steam ball in the following manner: Assuming one of the chambers be open to steam and full of water, the steam entering by the steam pipe and past the ball passes into the chamber and presses upon the small surface of water exposed, and depresses it without agitation (and therefore with little condensation) and drives it through the discharge valves into the rising main. The moment, however, the water in the chamber falls to the level of the opening in the branch leading to the discharge box, the steam blows through with a certain amount of violence, and as it is brought into intimate contact with the water in the discharge box an instantaneous condensation takes place, and the vacuum thus formed in the emptied chamber immediately pulls the control ball over on to the corresponding seat and cuts off further admission of steam, allowing the vacuum to be completed. Water immediately enters through the suction pipe, and, lifting the inlet valve, rapidly fills the chamber again. A similar operation has been taking place in the fellow-chamber, the period occupied by filling one chamber corresponding to that of emptying the other, and these operations continue alternately in the two chambers so long as the pump is supplied with steam and water. The alternations follow so rapidly and with such regularity that the stream of water is practically continuous.

When used for pumping sewage sludge the pump used should possess special features. In this class the passage and waterways are specially large and free. Fig. 38 illustrates the "free-way" pattern, whilst Fig. 38a shows the application of this class of pump in sewage work in connection with sprinklers for filters.

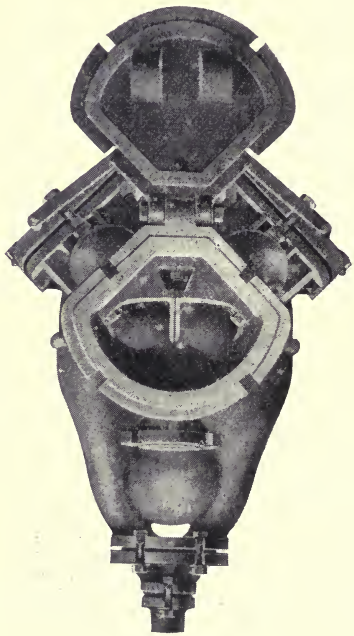


Fig. 38. "Free-way" Pulsometer Pump.

Tangye's Steam Pump.

These pumps are used in many installations, and especially in the process of sludging chemical precipitation and other sedimentation tanks, for pumping out the semiliquid therefrom, as at Kingston-on-Thames. For sewage purposes the "special" self-acting pump is recommended,

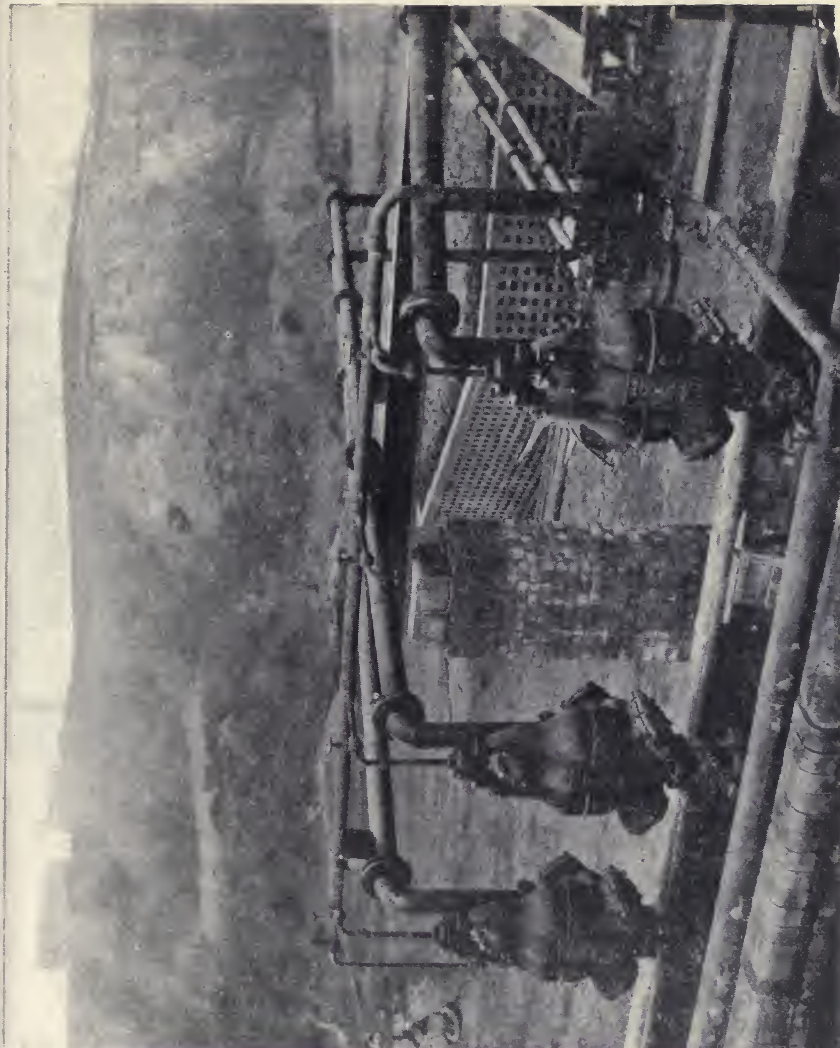


Fig. 38A. Application of Pulsometer Pump to Sprinklers.

as it is provided with means for easy examination in the shape of doors or covers so that the valves may be readily removed.

A "special" 12-inch stroke steam pump with suction inlet and delivery outlet at the front is suitable for working against "heads" of 300 feet; "head" meaning the total vertical height of suction and delivery, plus the friction of the liquid which is being passed through the pipes, bends, valves, etc.

The "Tan-gyro" centrifugal pump is from the same firm, and is intended to deal more particularly with varia-

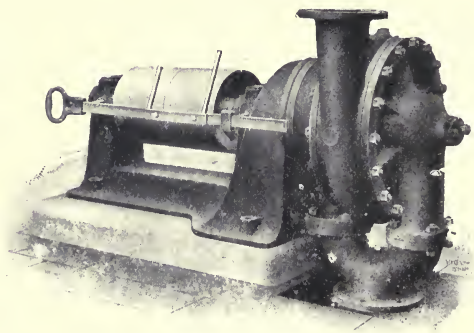


Fig. 39. Tan-gyro Centrifugal Pump.

tions in flow. Fig. 39 shows type "c," with two standards and two pulleys.

Dosing Syphons.

Dosing syphons are useful in cases where the effluent to be "fed" to sprinklers or other forms of distributors, or filters, may not be uniform in quantity, and consequently has to be collected in a "dosing" tank until sufficient in quantity to be discharged thereto. Dosing syphons should be constructed to work automatically or continuously, depending on the quantity of the effluent, and whilst this collection is taking place the sprinklers in connection are at rest.

Fig. 40 shows two of Jenning's "Dosing Syphons" of low draught, constructed to work with a depth of 6 inches of effluent.

Mather and Platt's Automatic Distributing Valves.

These valves are used for feeding filter beds. They are fixed in the wall of the distributing chamber, and each is provided with a can which actuates it. Fig. 41 shows ten valves connected to ten beds at the Tunstall works, where they are arranged to distribute the tank liquor over the ten filter beds in succession every fifteen minutes.

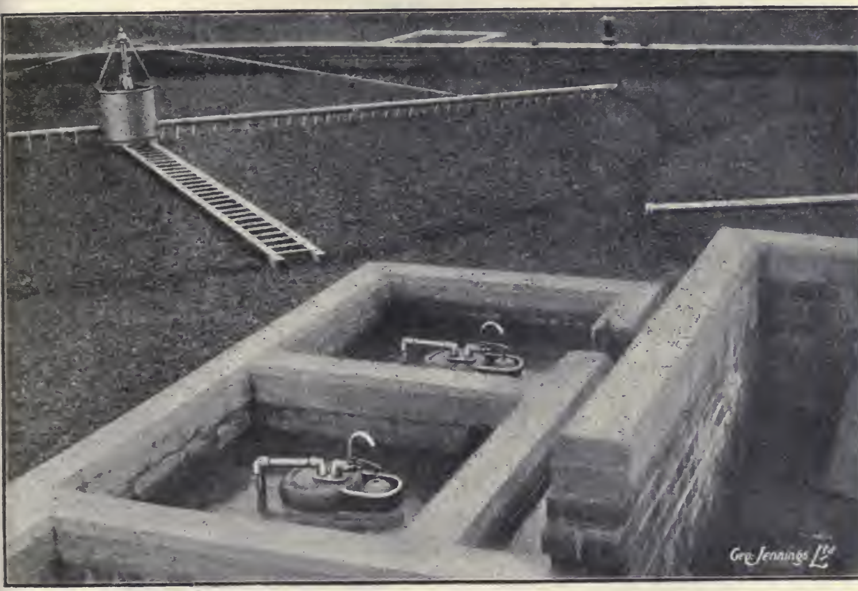


Fig. 40. "Dosing" Syphons.

Jennings' Patent Distributing Syphon.

This apparatus (Figs. 42 and 42A) is for distributing sewage from a dosing tank, or tanks, to bacteria beds, revolving distributors, etc., so that a succession of these may be utilised one after the other in regular sequence. Deep trap syphons are used, and operated by means of air valves mounted on a frame, as shown at 1, 2, 3, connected to the syphons. On the air valve lever, a striker is provided, against which the revolving cams (5) impinge. The cams on the shaft are caused to rotate by means of the rise and fall of liquid in the tank (10). Being positioned one in advance of the other, the cams start syphons one after the other, or in any desired order. Thus any number of filters or sewers will each receive automatically, and in turn, the entire contents of the tank. It will be seen that when used for sewer flushing this apparatus will effect a considerable saving in brickwork, as one tank would serve any number of sewers.

Fig. 41. Distributing Valves.

Kent's Intermitting Valves to Sprinklers.

These apparatus have been designed by Messrs. Kent, to economise the "head" and to facilitate the feeding of rotating sprinklers direct from tanks having large superficial area. One of these "dosing" valves, as they are also called, is sufficient to feed simultaneously and operate any number of sprinklers.

The apparatus consists essentially of three parts. Fig. 43 will illustrate them, and serve to explain them and their action :—

(1) SA Seating, through which the tank effluent is discharged.

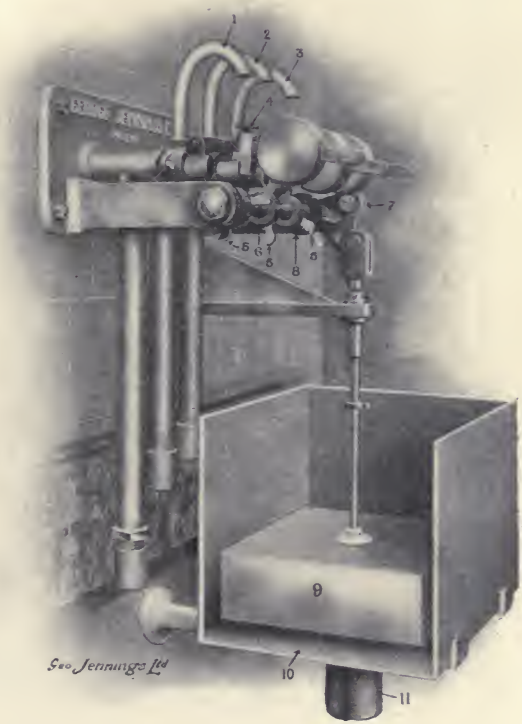


Fig. 42. Distributing Syphons.

(2) CA Valve Cap, balanced by the weights WW.

(3) FF two floats which carry two adjusting weights, AA.

The action of the apparatus when placed in a chamber which is in connection with a tank, is as follows :—

When the upper level in the septic or other tank is reached, the buoyancy of the floats is sufficient to overcome the force due to the weights AA and the frame to rotate, causing the cap, C, to lift, which releases the contents of the tank, and allows it to gravitate to the sprinklers. This discharge continues until a given lower level is attained.

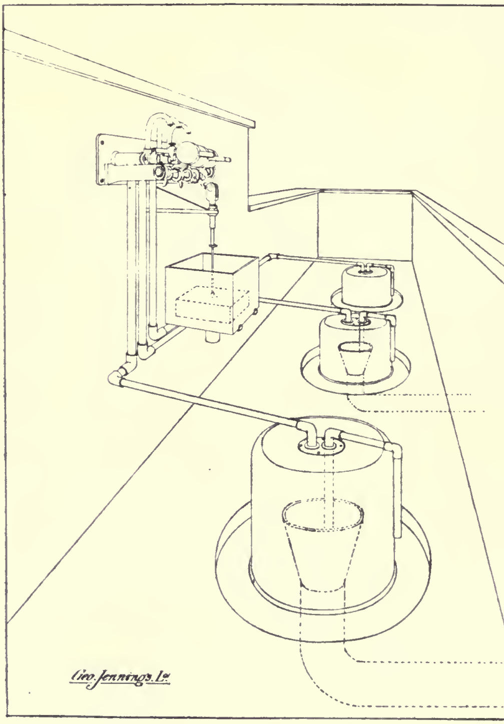


Fig. 42a. Distributing Syphons.

At each outlet from the distributing chamber which supplies the sprinklers, is placed a penstock (as Fig. 47)* to enable the discharge thereto to be regulated.

An alternative to this method is the use of alternating gear, in which case separate valves are used with each sprinkler, and the valves are made to operate in succession.

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* See p. 192.

Fig. 43b illustrates the employment of these intermitting valves for feeding and ærating filters, in which D is the Dosing Valve; G is a somewhat larger valve used for ponding up the filter effluent, and enabling the displaced air to be forced up through the filtering material; V is a non-return air inlet valve, through which a fresh supply of air comes after each discharge.

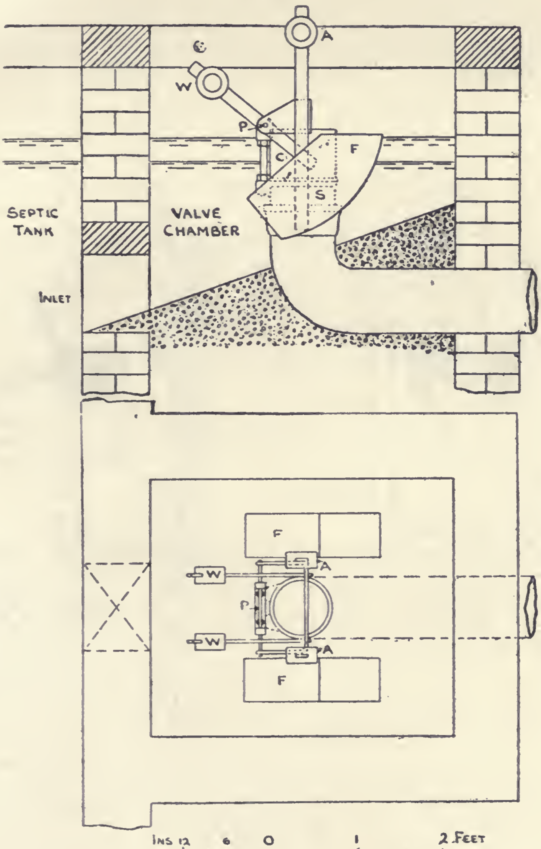

Fig. 43.

Fig. 43a shows plan of intermitting valve dosing to six sprinklers.

These valves are also useful for flushing sewers, by placing the same between the storm overflow from the detritus tank and the storm-water filters, and are shown in the plan of a small installation (Fig. 23)*, which also shows application to the various valves, whereby uniform distribution over the filtering material is aimed at.

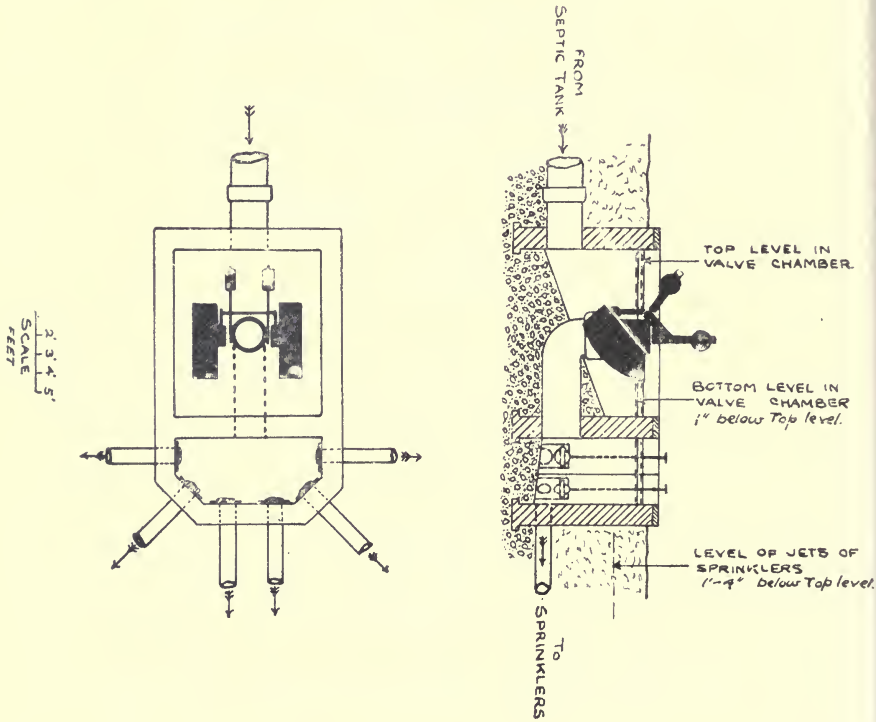

Fig. 43A. Showing Intermitting Valve Dosing to Six Sprinklers.

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* See p. 132.

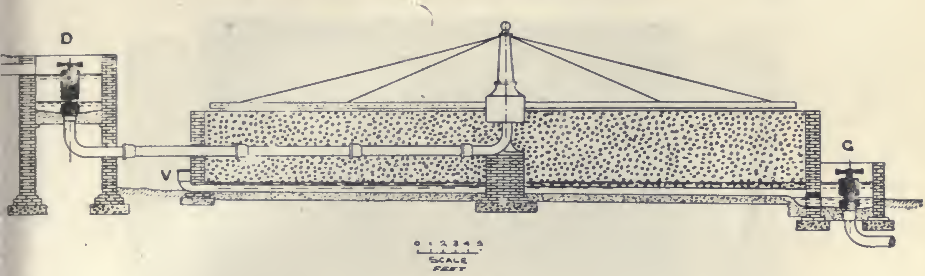

Fig 43B. Showing Dosing and Aeration of Filters by Intermitting Valves.

Jennings' Automatic Governor.

This apparatus is constructed to control the speed of filter-bed distributors when dealing with varying flows of tank effluent. The "governor" is out of action when the distributor is working with the minimum flow, but an abnormal flow causes the governor to bring about a reduction in the speed, by applying the brake, which remains in action until the flow falls back to the minimum. Beyond this the "governor" does not influence the quantity of effluent which passes through the distributor (Fig. 44).

Jennings' "Compensating Arms" to their Sprinklers.

This apparatus is fixed to sprinkler centres to control automatically variations in flow of the effluent passing into the sprinkler.

When there is an increase in the flow above the normal these two "compensating arms" automatically come into action, and, in conjunction with the two arms of the sprinkler, distribute the increased volume over the bed.

Fig. 45 illustrates a Jennings' revolving Sprinkler, showing its centre fitted with "compensating arms," and Fig. 45a shows such a sprinkler at work, able, by the aid of these "arms," to distribute 1000 gallons per square yard of filter per day.

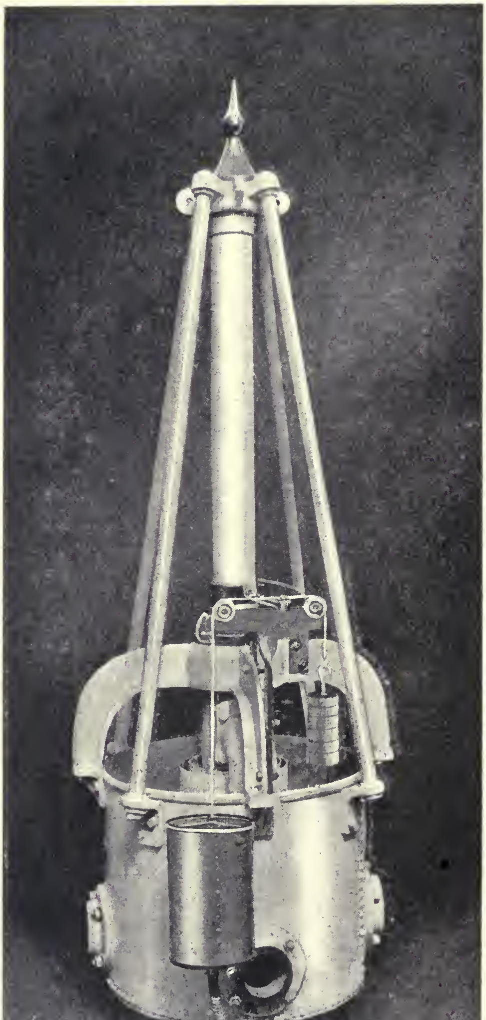

Fig. 44. Jennings' Automatic "Governor."

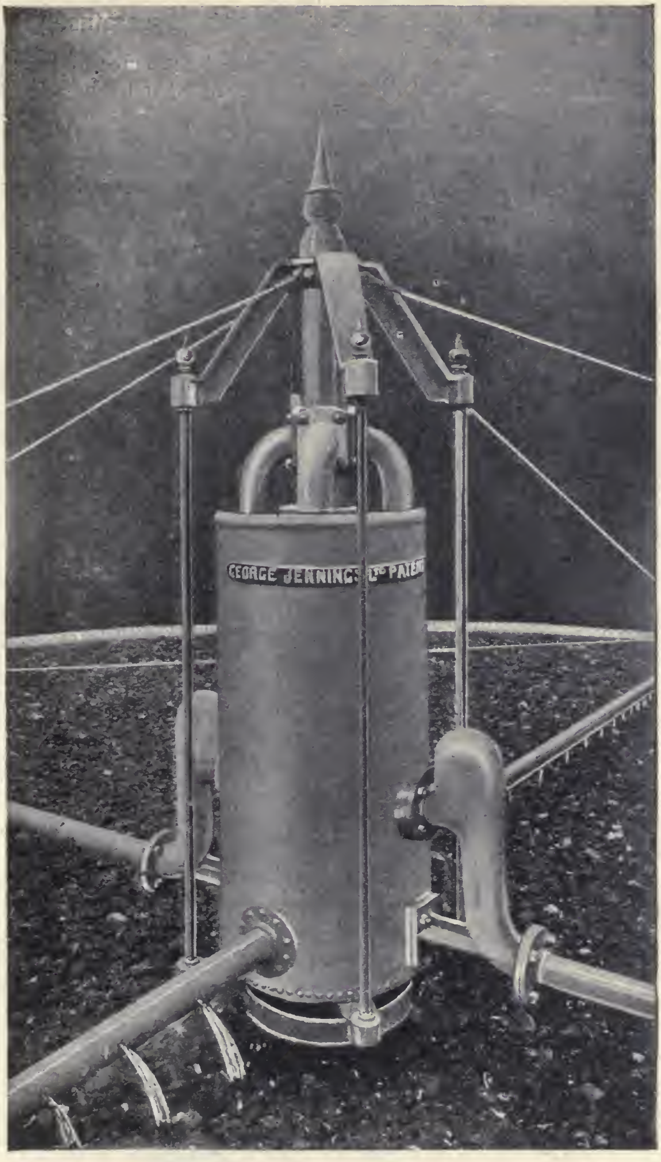

Fig. 45. Sprinkler with "Compensating" Arm.

Garfield's Automatic Screening Apparatus.

This apparatus is specially designed for screening waste water or sewage containing a large quantity of fibrous matter

Fig. 45A. View of Revolving Sprinkler with "Compensating" Arm.

—corks, brushes, cloths, etc. The illustration (Fig. 46) is from a photograph of an installation of two sets, at large

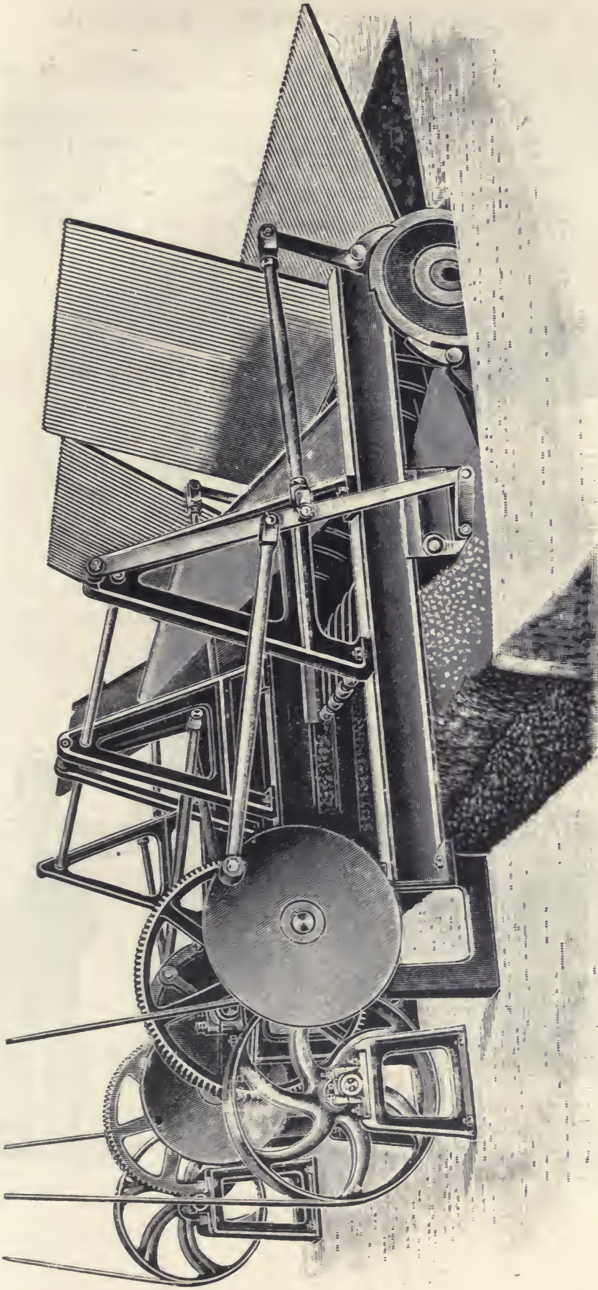

Fig. 46. Sewage Screening Apparatus.

sewage works. The construction of the apparatus is as follows :—

Six bar screens are fixed to a centre shaft, arranged to rotate. Fixed on the end of this shaft is a large ratchet wheel. By means of a ratchet pawl, fixed on an oscillating lever, and worked by power through gearing and disc crank, the screens are intermittently rotated a part of a revolution.

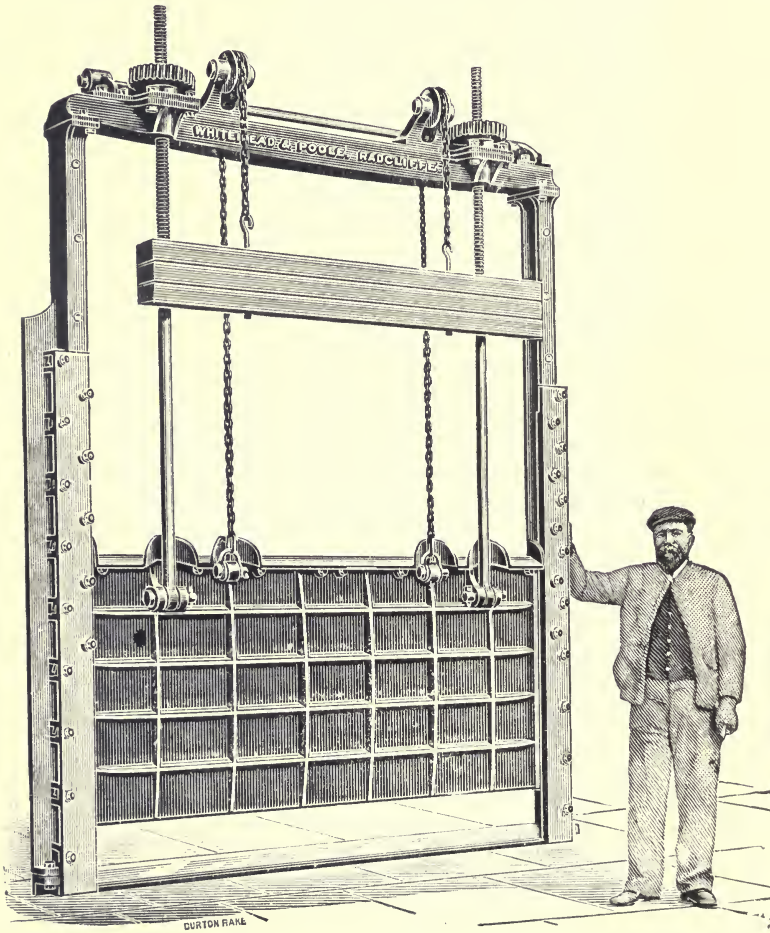

Fig. 47. Screw Penstock.

It is arranged that two screens are always down in the channel at one time. By means of the slow-moving gear they remain stationary for a short period, until the ratchet gear operates and rotates the screens. The movement is only sufficient to bring the first screen, which is covered with screenings, to the horizontal position. The ratchet then disengages, and the return motion of the swinging lever actuates a sliding cleaning rake, which efficiently and effectually wipes off all the *débris* into a trough or conveyor fixed across the channel.

Penstocks.

Penstocks are used for releasing tank contents at the time of discharge, etc.

In Fig. 47 the frame is of heavy channel section cast-iron, built up in segments, with all joints carefully machined and fitted with turned-hard brass face, secured with copper pegs. The gate is of cast-iron, cast in one piece, being heavily ribbed on back, to prevent springing, and having wedge pieces cast on back, for engaging with adjustable wedge plates on body, to force joint faces together when closed.

There are various other forms of penstocks in use.

CHAPTER XL.

Salient Features of Some Typical Installations.

Tables XIV.-XVI. have been compiled by the writer from various details and descriptive matter contained in the Fifth Report of the Fifth Royal Commission. It is a fact worthy of notice that while it is apparent that the respective works were chosen because each was evidently looked upon as being typical in its nature, yet the Commissioners only reported on one of the smallest—Prestolee, where an extremely weak sewage from five hundred persons is dealt with—as "very good." Eight others are "good," whilst the rest are either only "fair," "moderate," or "unsatisfactory," which latter opinion was called forth by the closed septic tank followed by single contact bed treatment at Slaithwaite, Newton-le-Willows, and Halton. On the whole, it seems evident that the results from the chemical treatment works under observation were more satisfactory than septic or other sedimentation processes.

The Tables show at a glance the principal features of each installation.

With regard to Table XVII., the writer wishes to acknowledge the kindness of the Local Government Board for Ireland in supplying him with the details there shown. It is a feature worthy of notice that the apparatus used and the general construction of the installations show that the most up-to-date methods are employed in the majority of cases. In only one (Dublin City, which is apparently the oldest installation) is the sewage precipitated by the addition of lime. With the Belfast sewage the process is screening and sedimentation, and the outfall is into Belfast Lough.

TABLE XIV.—*Chemical Treatment Installations.*

Installation	Character of Sewage.	Population Draining to Works.	Avge. Dry Weather Flow per 24 hrs. in gals.	Chemical used.	Contact Beds or Filters.	Media.	General Result of Treatment.
Calverley	Strong slop water	2,300	12,000	Alumino-ferric	Single contact	Boiler Clinker	Poor
* Guildford	Strong domestic with brewery refuse and other trade wastes	6,000	400,000	Do.	Double contact and Filters and land	(a) Polarite and sand (b) Coke and gravel	Good
Hendon	Strong domestic with wastes from a very large number of laundries	23,500	950,000	Do.†	(1) Contact or (2) Secondary filtration	Coke breeze, pan breeze (a) Burnt ballast (b) Do. covered with 12 in. of soil	Generally Good
Horfield (Bristol)	Domestic with laundry refuse	2,500	38,000	Do. and continuous flow subsidence	Filter	Gas works clinkers	Fair
Normanton	Domestic (Soapy slop water)	12,600	175,000	(1) Do. (2) Do. and	Filter Filtration through land	(top) sand (middle) Polarite sand (bottom) Pebbles	Fair
Withnell	Strong Domestic	1,600	15,000	(1) Alumino-ferric and quiescent subsidence (2)	Filter and land Double contact of crude sewage & land	Sand and Polarite	Very Fair

* Part septic system.

† A solution of copperas, equivalent to ·5 to ·75 grains of crystallized salt per gallon is also added on three day per week.

TABLE XIV.—*Chemical Treatment Installations* (continued).

Installation	Character of Sewage.	Population Draining to Works.	Avge. Dry Weather Flow per 24 hrs. in gals.	Chemical used.	Contact Beds or Filters.	Media.	General Result of Treatment.
* York	Domestic (greater part)	80,000	3,750,000	Alumino-ferric and lime in continuous flow tanks	Filters	Clinkers, cinders, broken bricks, slag and gas coke	Good
Rochdale	Strong (very) manufacturing & wool scourings	52,000	1,450,000	Alumino-ferric and brown oil of vitriol; and continuous flow settlement	Double contact or land	Gas coke	Good
† Chorley	Domestic and from cotton mills	27,000	900,000	Sulphate of Alumina and quiescent settlement	Filters	(a) Polarite and sand (b) Do. and gravel (c) Coke breeze	Good
Maidstone	Domestic and wastes from breweries, tanneries and paper mills	34,000	1,500,000	(1) Lime and continuous flow settlement (2) Crude sewage on	Double contact do.	Furnace clinker	Fair
Kingston-upon-Thames	Domestic and brewery and tannery wastes	53,450	2,750,000	"A.B.C." Process (alumino-ferric blood, charcoal clay) and continuous flow settlement	Single contact	Coke furnace clinker	Good

* A small proportion—500,000 gallons—treated primarily in septic system tanks.
† Installation briefly described at p. 262.

TABLE XV.

Septic Treatment Installations.

Installation	Character of Sewage.	Population draining to works.	Average dry weather flow per 24 hrs. (in gals.)	Open or Closed Tanks.	Contact Beds or Filters.	Media.	General Results of Treatment.
Accrington	Strong domestic	46,300	1,180,000	Open	Filters	Clinkers, also coke	Good
Guildford	Strong domestic and large quantity of brewery and trade refuse	16,000	400,000	Open	Double contact followed by shallow filters and land	Burnt ballast clinker Burnt ballast, fine clinker, and sand	Good
*York	Strong domestic	80,000 (but part only)	500,000	Open	Filters	Furnace clinker and cinder	Good
Andover	Domestic and some brewery refuse	5,000	150,000	Closed	Single contact and land	Locomotive furnace clinker	Poor
Exeter	Strong domestic	38,000	1,300,000	Do.	Do.	Furnace clinker and coarse gravel	Poor

* Part by Chemical Precipitation.

TABLE XV.—*Septic Treatment Installations* (continued).

Installation	Character of Sewage.	Population draining to works.	Average dry weather flow per 24 hrs. (in gals.)	Open or Closed Tanks.	Contact Beds or Filters.	Media.	General Results of Treatment.
Exeter	Strong domestic	1,500	50,000	Closed	Single contact	Clinker coke breeze	Satisfactory for weak sewage
Knowle (Bristol)	Domestic	1,600	41,000	Do.	Filters	Coarse washed destructor clinkers	Poor
*Prestolee (Bury R.D.C.)	Extremely weak slop water	500	18,000	Do.	Do.	Cinders and gravel	Very Good
Hartley Witney	Domestic and deal of brewery waste	1,600	50,000	Closed	Single contact and land	Gas works furnace clinkers	Moderate
Caterham Barracks	Exceptionally strong domestic	1,300	17,000	Do. and cultivation tank.	Filters	Coke	Fair
Slaithwaite	Domestic slop water	3,000	140,000	Closed	Single contact	Furnace clinkers and ashes	Unsatisfactory

* Part by Chemical Precipitation.

TABLE XVI.

Other Systems of Treatment.

Installation	Character of Sewage.	Population Draining to Works.	Avge. Dry Weather flow per 24 hrs. in gals.	Primary Treatment.	Contact Beds or Filters.	Media	General Result of Treatment
* Clifton (Barton-upon-Irwell R.D.C.)	Strong slop water domestic	2,000	22,000	Continuous flow filtration	Filters	Cinders and gravel	Good to Fair
Halton (nr. Leeds)	Mainly slop water	2,000	35,000	Continuous flow settlement†	Double contact and land	Coke, clinkers and stone	Unsatisfactory
Oswestry	Domestic, with wastes from breweries & tanneries	9,800	350,000	Continuous flow settlement	Double contact	Cinders	Fair
Little Drayton	Strong slop water domestic	1,550	12,000	Continuous filtration through a	Filter	Granite chippings	Inexpensive Good to Fair
Newton-le-Willows	Slop water	9,000	210,000	Filtration of slightly settled sewage by	Single contact	Furnace boiler cinders	Unsatisfactory
Hampton	Strong domestic	6,500	180,000	Crude sewage by	Triple contact	Do.	Good

* Installation briefly described at p. 210.

N.B.—The proportionate difference in quantity in the dry weather flow in all three Tables appears to be due to the variations in the quantity of the water supplied per head, and the number of water closets.

† The sedimentation tanks should be cleaned out once a week. The period of flow should generally be from 10 to 15 hours.

TABLE XVII.

List of Towns and Villages in Ireland with Sewage Disposal Works; showing Population, Sanitary Authority, Nature of Outfall and Method of Disposal.

Place.	Population.	Sanitary Authority.	Outfall.	Method.
Armagh	7,588	Armagh Urban District Council	Small stream	Tanks, contact beds and land
Ballinacurra (Limerick)	—	Limerick No. 1 Rural District Council	Tidal stream	Tanks and sprinklers.
Ballybay	1,208	Castleblayney Rural District Council	Lough	Tanks and Stoddart's filters
Ballymena	10,886	Ballymena Urban District Council	River Braid	Tanks and rough filter
Belfast	349,180	Belfast Corporation	Belfast Lough	Screening and sedimentation
Birr	4,438	Birr Urban District Council	Stream	Tanks and land
Blackrock and Kingstown	26,096	Blackrock and Kingstown Main Drainage Board	Sea	Tanks (tidal discharge)
Bundoran	896	Ballyshannon Rural District Council	Sea	Tank
Castleblayney	1,576	Castleblayney Urban District Council	Lake	Tanks, sprinkler and land
Clones	2,068	Clones Urban District Council	Stream	Tanks and contact beds
Cork (Rural District)	—	Cork Rural District Council	Tidal river	(a) Tanks; (b) Tanks and contact beds
Delgany	207	Rathdown No. 2 Rural District Council	Stream	Tanks, contact beds and land
Dublin (City)	290,638	Dublin Corporation	Tidal estuary	Precipitation with lime
Dunmurry	1,105	Lisburn Rural District Council	River	Tanks, contact beds and land

TABLE XVII—*Continued.*

List of Towns and Villages in Ireland with Sewage Disposal Works; showing Population, Sanitary Authority, Nature of Outfall and Method of Disposal.

Place.	Population.	Sanitary Authority.	Outfall.	Method.
Enniskerry	235	Rathdown No. 2 Rural District Council	River	Tanks, contact beds and land
Foxrock	—	Rathdown No. 1 Rural District Council	River	Tanks and contact beds
Greencastle	—	Belfast Rural District Council	Belfast Lough	Tanks and sprinkling filters
Greystones	856	Rathdown No. 2 Rural District Council	Sea	Septic tanks
Greystones (Burnaby Estate)	—	Rathdown No. 2 Rural District Council	Sea	Septic tanks and contact beds
Howth	1,166	North Dublin Rural District Council	Sea	Tanks
Kildare	1,576	Naas No. 1 Rural District Council	Stream	Tanks, contact beds and land
Lisburn	11,461	Lisburn Urban District Council	River Lagan	Tanks, contact beds and land
Macroom	3,016	Macroom Urban District Council	River	Tanks, contact beds and land
Milford (Donegal)	366	Milford Rural District Council	Stream	Tanks, contact beds and land
Mitchelstown	2,146	Mitchelstown No. 1 Rural District Council	Stream	Tanks and sprinkling filters
Naas	3,836	Naas Urban District Council	Stream	Tanks and land
Newbridge	2,903	Naas No. 1 Rural District Council	River Liffey	Tanks and land
Tipperary	6,281	Tipperary Urban District Council	Stream	Tanks and sprinkling filters

CHAPTER XLI.

Some Typical Works Described.

Hereunder are very briefly described some of the features of installations for treating sewage by chemical precipitation, septic tank, and continuous flow filtration. It may be that some readers would like to inspect any installation near to them, and a request that the favour of permission to do so be given would doubtless meet with acquiescence on the part of the surveyor.

Chorley.

The sewage on arrival at the installation, after passing a storm overflow, passes through *detritus tanks* constructed in duplicate, measuring 42 feet by 4 feet by 4 feet, with a capacity of 4,200 gallons. The grit, etc., deposited by means of a screen is removed once a week by the aid of a chain pump.

Chemical precipitation follows in eight tanks, each 90 feet by 48 feet by 5 feet 3 inches, with a capacity of 140,000 gallons, constructed of brick and cement with a concrete bottom sloping towards the outlet end. The tanks are filled in rotation; they remain full, in dry weather, from two to four hours. In wet weather one hour is considered sufficient, as the precipitated sewage settles more rapidly.

The precipitation effected at this installation is described as "uniformly excellent." The method of sludging the precipitation tanks has been dealt with elsewhere.*

The filtration of the precipitation tank effluent is effected on fifteen filters arranged in five sets of three each. Nine of these are 57 feet by 16 feet; and six 114 feet by 16 feet; all being 3 feet in depth. They are constructed of brick walls with cement bottoms, and lie below the level of the ground. The filters in each series are connected with each other by openings under the two dividing walls. Six rows of 3-inch horse-shoe drains, laid the whole length of the bed, and falling to the outlet pipe, are provided for the under draining. The filters are fed by fixed troughs over the surface of the bed.

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* See p. 141.

The average amount of effluent dealt with per square yard per 24 hours is 525 gallons, resulting in the oxidation of about four-fifths of the organic and about half the nitrogeneous matter. The effluents were reported as well nitrated.

It will be noted (Table XIV.) that Polarite (mangetic oxide of iron, alumina, magnesia, carbon, silica, and lime) is employed as a filtering medium. Comparisons were made to see what difference was effected between it and coke as regards the purifying properties, the result being "that neither effluent shows any marked superiority over the other." For the installation generally we read: "Good results are obtained in every part of the process, and little or no nuisance arises from it."

Prestolee.

(Bury Rural District Council.)

This is only a very small installation for treating the sewage of some five hundred persons, the sewage from whom amounts to 36 gallons per head per day. It is extremely weak in character; in fact, almost entirely slop-water. The water supply is $17\frac{3}{4}$ gallons per head, and is drawn from the Bolton Corporation Water Works. It is only slightly hard in character, on an average some three degrees per gallon. The average daily dry-weather flow of sewage is 18,000 gallons.

One of the features of the system is that the average flow is of a very even character. Even in periods of heavy rains the variation is very slight when compared with other works. This is due to the fact that the gradient is low, and that a very large quantity of subsoil water enters the sewers. All storm water is treated, and amounts to three or four times the dry-weather flow.

The sewage is first received into the single detritus tank, constructed of brick and cement, with a concrete bottom. A scum board and a $\frac{3}{4}$-inch screen is fitted thereto. Its size is 9 feet by 5 feet, with 3 feet 6 inches depth of water.

The system is worked day and night, and the arrested matters in suspension, of the usual kind, which will not pass the screen, are removed from the detritus tank once a week by means of a scoop.

There is one septic tank, which is also worked day and night, and, despite this, nearly three years' continuous use has not necessitated its being sludged. The tank is of the following dimensions:—38 feet by 10 feet, with 7 feet depth of water. Like the detritus tank, it is constructed of brick and cement.

There the sewage is treated by anaerobic bacteria, the tank being covered with a brick arch, on top of which is spread a layer of soil; the interior is fitted very simply. The incoming sewage comes in through a single pipe at the water level, and is discharged through a pipe at the same level at the opposite end, which is protected by a scum board. Due, doubtless, to the very dilute nature of the sewage, the action of the bacteria brings about a considerable amount of digestion in the solid matter, and hence there is not proportionately the formation of the usual quantity of sludge.

For the like reason the bacteriological analyses show the sewage to be very weak. The dry-weather flow of 18,000 gallons per 24 hours passes through the tank at the rate of .34 inches per minute, or once in 22 hours.

There are three filters built below the level of the ground, brick and cement being used in their construction. The size of each is 27 feet 9 inches by 25 feet 8 inches, with a 5-feet depth of material, consisting of: (Top) 1 foot fine cinders $\frac{1}{4}$ to $\frac{1}{8}$ inch diameter; (Middle) 3 feet mixed cinders; (Bottom) 1 foot rough cinders. It is drained by one main drain, which is carried diagonally across the concrete bottom, and the septicised effluent is fed to it from two branch collectors fixed on either side. The filters are only worked one at a time, for a period of 24 hours, during which the other two are "resting" for the purpose of æration. This is ensured in a very crude manner, and the incoming air utilised for this purpose only gains access from the top downwards, through the interstices of the filter, or upwards by way of the outlet valve, which is left open at all times for the purpose. The incoming effluent is distributed over the surface of the filtering material by means of a fixed distributor, a half-pipe of 6-inch diameter, which is laid diagonally on top of the bed. Three similar pipes serve as channels for the conveyance of the septicised liquor to all parts of the bed. After the day's working, these channels are cleared out.

The surface material becomes clogged by a thin coating of sludge-like matter within a fortnight, if the weather is wet, otherwise in about a month. It is removed by the use of a shovel, and the thin layer of cinders which is removed with it is replaced by another layer of cinders. Those removed are placed at the side of the filters, air dried, riddled, and replaced in due course. The effluents are, generally speaking, very high class, and it is very rare that any smell is observed, and then only a slight one, either earthy or of sulphuretted hydrogen. They also show very good bacteriological results.

Despite the simple construction of the bed, the resulting "finished" effluent is well ærated, and at the outfall causes no growths. The effluents are also weak in bacteria. These results are of necessity exceptional, due almost, if not entirely, to the extreme weakness of the sewage, and cannot be hoped to be achieved with many installations, even although the circumstances may be to a large extent the same. At the same time, the results from such simply and economically constructed works are an object-lesson in the treatment of sewage from small communities on an economical basis.

Macclesfield.

The population here is some 36,000, and the average dry-weather flow about 1,000,000 gallons per 24 hours. The main outfall into the works is a 24-inch stoneware pipe, having a gradient of 1 in 400. Overflow sills are fixed at the entrance to the works, and divert the excess of storm water into the adjacent river Bollin. The sewage to be dealt with passes into the *septic tanks*, having each an area of 65 feet by 44½ feet, and an average depth of 8½ feet. Their walls are of Staffordshire bricks, and the floors of 12-inch concrete, paved with 2-inch blue bricks laid in cement. At the lowest corners of these tanks are the sludge outlets, which communicate, by 12-inch cast-iron pipes, to the sludge pit. The tank liquor is discharged into the measuring chamber in which are four Mather and Platt's Distributing Valves (Fig. 41)*, acting with one of their Automatic Measuring Valves, which feed four *filter beds* is succession. These filter beds are similarly constructed to the septic tanks. The walls have headers left out at every few courses to ærate the filter, and at the ground level, to allow of the discharge of the finished effluent. These beds each possess an area of a quarter-acre, and an average depth of 6½ feet. The filtering material is broken stone from neighbouring quarries, some 3,000 tons of which are used in each filter. The beds are fed by a Mather and Platt Automatic Revolving Spreader with four arms. So as to prevent interference with its

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* See p. 181.

automatic working, an electric motor is fixed at the centre of each spreader. Some $2\frac{1}{2}$ feet is a sufficient "head" between the water-level in the measuring chamber and the

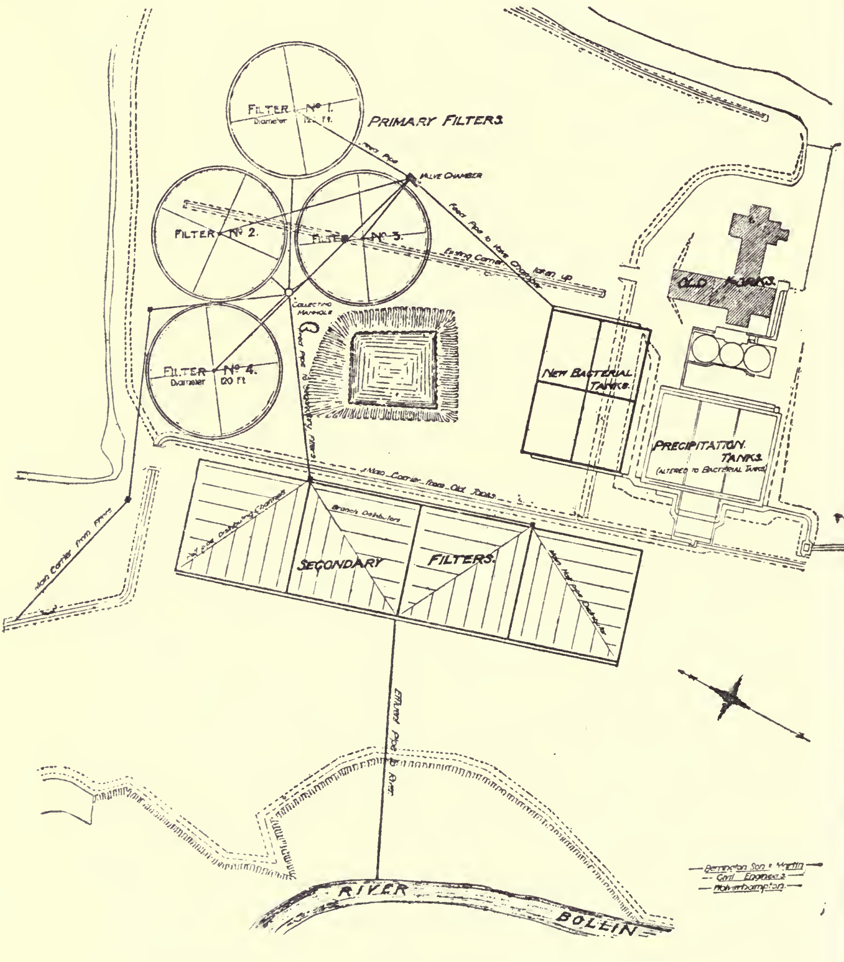

Fig. 48. General Plan of Macclesfield Works.

surface of the filter beds, to enable the sewage automatically to work the spreaders.

The effluent from the four filters is discharged by gravitation into one secondary filter, which is rectangular in construction, one acre in area and 1 foot 9 inches in depth, in which the filtering medium is broken clinker, with a surface layer of fine-grade Pottery "saggars." The final effluent is discharged into the River Bollin.

Fig. 48 illustrates a general plan of the work.*

Burnham.

The system here deals with an average dry-weather flow of 90,000 gallons per day, though the works have a maximum capacity of 270,000 gallons, so designed that any excess above this amount is carried to the storm-water bed, 86 feet long by 40 feet wide, and 3 feet deep. Three *detritus* chambers first receive the sewage, which is then passed through a distributing channel into three *septic tanks* by cast-iron submerged inlets, regulated by disc valves. The tanks are 45 feet by 15 feet by 6½ feet; the resulting sludge is valved off to sludge lagoons. The tanks are covered ones, the roofs being flat and covered with ferro-concrete.

Fig. 49. The "Newham" False Floor Tiles for Ventilating and Drawing Bacterial Filters and Contact Beds.

The septicised effluent passes under double scum boards, over a stone weir, and thence through ports, fitted with automatic "cut-offs" and recorders, to the measuring chambers, where it is held up until it amounts to 750 gallons in each, when automatic valves discharge the same on to the *filter beds*, which are composed of graded furnace clinker, with large-sized pieces built up as an outside wall. The

* Reproduced by kind permission of the Engineers, Messrs. Perrington, Son, and Watney, M.M.Inst C.E., Wolverhampton and Westminster.

sloping floor of concrete has 24 rows of Newham tiles (Fig. 49), which radiate from the centre, and these are used

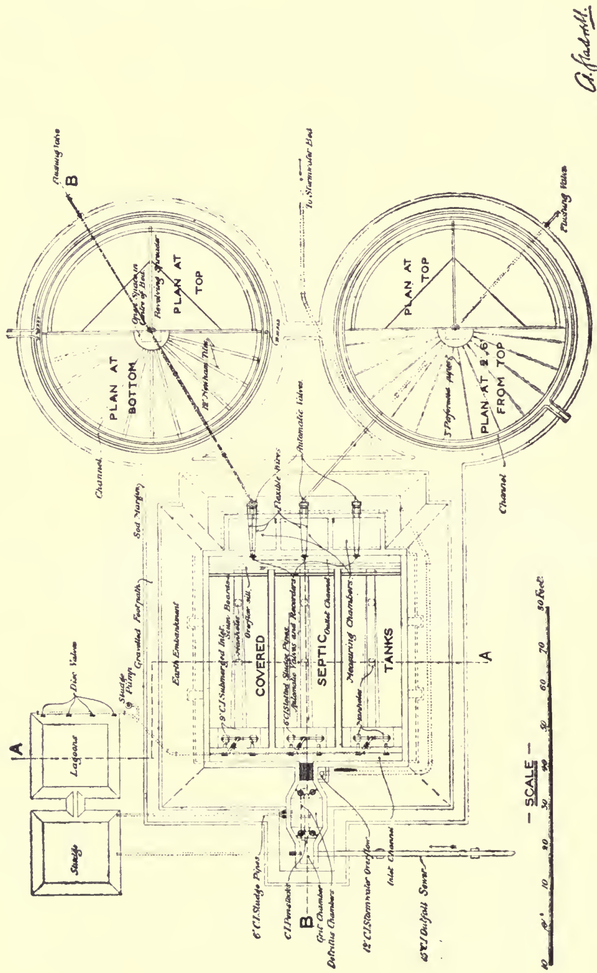

Fig. 50. Plan of Burnham Sewage Works.

as ventilators as well as outlet chambers. (These tiles are interlocking, and are used for ventilating and draining contact beds and filters.)

Messrs. Mather and Platt's Automatic Rotating Spreaders, some 53 feet in diameter, are used, and the filtered effluent is finally dealt with on land.

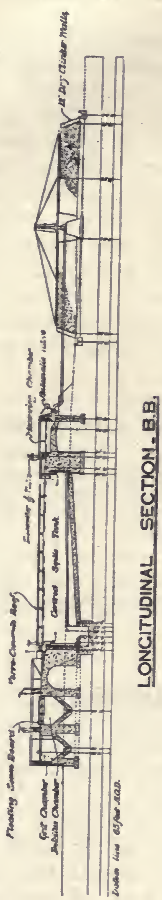

Fig. 50A. Longitudinal Section of Burnham Sewage Works.

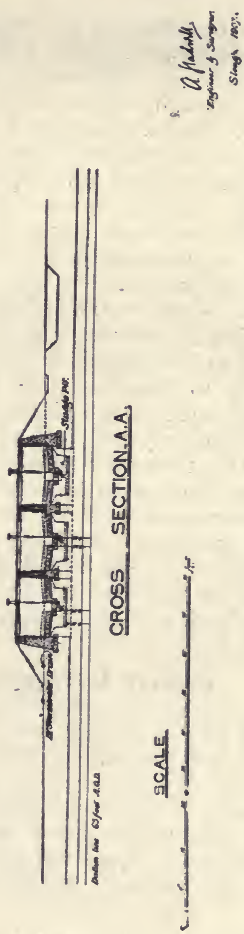

Fig. 50B. Cross Section of Burnham Sewage Works.

Figs. 50, 50a, and 50b illustrate the plan of the Burnham Sewage Installation, with longitudinal and cross sections*.

Continuous Flow and Settlement Filtration. Clifton.

(Barton-upon-Irwell Rural District Council.)

There the strong slop-water domestic sewage, mixed with soft moorland water, from some 2,000 persons, is treated by continuous flow settlement, followed by continuous flow filtration through furnace clinker and cinder, clay-soil gravel and sand. The settling tank has a capacity of 4,875 gallons, and receives the whole of the sewage, both day and night, except when stopped for sludging, which is done about every five weeks owing to the sludge beginning early to ferment. This takes one man some sixteen hours, and during that time the crude sewage is sent direct to one of the four filters.

The *filters* are fed in a very simple way, and, owing to the fine material on their surface, no mechanical distributor is used, but the effluent is delivered from one or more points direct on to the surface of the bed in use.

Owing to the fact that the suspended solids in the incoming sewage are retained by the fine surface material, from which they are periodically scraped, and that only some 15½ gallons per square yard are treated thereon per 24 hours, the system is looked upon as satisfactory, given skilful management, for a small community.

The system is considered to have a peculiar interest of its own, both in its chemical and bacteriological aspects, owing to the fact that it is an intermediate one between land filtration and artificial treatment.

General Arrangement of Installation.

Figs. 51 and 51a will perhaps clearly illustrate an average installation for a small town. The system is on gravitation principles. We have first the detritus tank, which should be fitted with suitable screening and inlet and outlet valves. Thence the sewage passes into the bacterial or other sedimentation tank, from which the effluent passes through a measuring chamber, fitted with some sort of measuring

* Reproduced by kind permission of Mr. A. Gladwell, the Engineer and Surveyor.

valve, and thence the liquid is distributed over the filter-beds by means either of a stationary or a revolving distributor, the latter actuated either automatically by the "head" of incoming tank effluent, or by the use of some motive power.

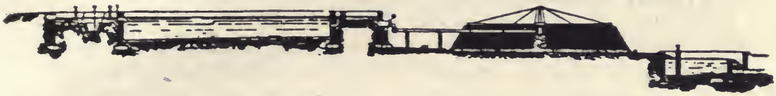

Fig. 51A. Section of Three "Filters."

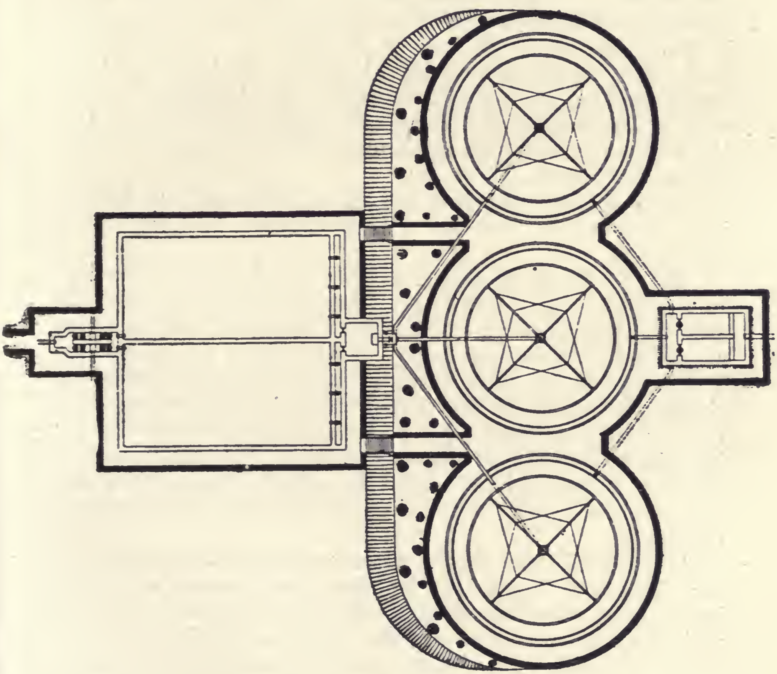

Fig. 51. General Arrangement of Three "Filters."

CHAPTER XLII.

Present Position of Knowledge of Sewage Treatment.

From what has been said in these pages, it will have been seen that the scientific treatment of sewage is still in many respects in its infancy. Valuable as have been the results attained by artificial methods, considerable darkness still overshadows them. Particularly is this so in relation to the work carried out on contact beds and percolating filter beds. Up to recently it was concluded that the work of nitrification was performed solely by bacteria; but now, although but little has yet been discovered as to the manner in which the ammonia, carbon dioxide, etc., are produced in the early stages of fermentation during the breaking down and liquefying of the organic solids in suspension, it has come to be realised that there are associated with the little-known species of purifying bacteria certain less-known kinds of insects, worms, larvæ, etc.

Although but little is known as to the division of labour, it is evident that they share between them the process of nitrification.

Mr. F. Wallis Stoddart, F.I.C., has been good enough to send the writer (May, 1911) the conclusions to which he has come as the result of a series of laboratory experiments, conducted continuously for more than a quarter of a century (in his own words) "to throw light upon the changes occurring in the sewage filter," and "to ascertain the manner in which the process of nitrification can be brought to the highest degree of activity, and the extent to which it is affected by conditions such as temperature and concentration, which occur naturally in the course of sewage treatment."

"An inclination has been shown recently," continues Mr. Stoddart, "especially by those investigators who attribute a chief share in sewage purification to physical agencies to belittle the practical importance of nitrification.

"The evidence, however, is overwhelming that, useful as the preliminary partition of sewage constituents may be, the final disposal of the putrescible matters is *entirely the work of living organisms*, and, in the main, of *bacteria*; and, further, that this is especially true of the soluble impurities contained in the clarified sewage which is more particularly the seat of the process of nitrification."

As regards the work of living organisms in the process of oxidation, this confirms what the author had already written some months before the receipt from Mr. Stoddart of the results of his experiments.

It is not intended to set out here in any detail the means by which he came to the conclusions arrived at; but one or two of the "conclusions as to sewage disposal" may be usefully set down.

Mr. Stoddart refers to the fact that the preliminary treatment should serve a two-fold purpose—(1) the elimination of the solids; and (2) the prevention of the formation of gelatinous and other matters in the effluent when on the filter, which tend to settle in and clog the interstices of the filtering media, and thereby impede the process of aeration. which is so essential to the efficient working of the filter.

He contends that "the application of the liquid to the filter should be by drops or very fine streams, and should never be interrupted. An intermission of even ten minutes appreciably reduces the efficiency of the filter." And "thence tippers, mechanical sprinklers, and all such appliances as cause interruption in the flow of liquid lower the efficiency of the filter."

The writer opines that this assertion will form, in due course, a much-debated and debatable point.

"The liquid should be applied to the medium immediately after comminution to get the maximum effect," he states, adding that it is a mistake to place the filtering medium much below the comminuting apparatus with the idea of promoting aeration.

"In practice for mechanical reasons, it would seem prudent not to exceed a depth of 12 feet, but this figure should be approached as nearly as possible."

General Conclusions of the Fifth Royal Commission.

The conclusions of the Fifth Royal Commission on Sewage Disposal are in many ways disappointing. It is possible that too much has been looked for as the results of their very extended labours, but, so far, these results were summarised in their Fifth Report issued in 1908, as follows:

"We are satisfied that it is practicable to purify the sewage of towns to any degree required, *either by land treatment or by artificial filters,* and that there is *no essential difference* between the two processes, for in each case the purification, so far as it is not mechanical, is chiefly effected by means of micro-organisms.

"The two main questions, therefore, to be considered in the case of a town proposing to adopt a system of sewage purification are, first, what degree of purification is required in the circumstances of that town, and of the river or stream into which its liquid refuse is to be discharged; and, second, how the degree of purification required can in the particular case, be most economically obtained."

One result of this conclusion has been the very great modification of the requirements of the Local Government Board as regards the construction of sewage disposal installations.

The decision as to what course should be pursued to deal with the various classes of sewage resulting from the admission thereto of the numerous manufacturing waste liquors is awaited with much interest; as is also the Commissioners' decision as regards the contamination of edible shellfish layings.

CHAPTER XLIII.

Points in Designing Works.

At the present juncture we can set forth the principal factors, which must be taken into consideration in designing purification works.

In the case of both town and private installations the question of cost will always loom very largely; in the latter more particularly. But, at the same time, it should not, where possible, come in the way of laying down the most satisfactory system for the work in hand; because this may be the cause of much ultimate harm and extra cost, especially in the production of a satisfactory effluent; for this, after all, is the ideal which it is necessary always to have in mind, both in designing and carrying on works for the treatment and disposal of sewage. It may be considered that three chief points must be borne in mind when designing purification works for towns and villages:—(1) Most satisfactory method to employ—(a) application to land, (b) chemical precipitation, (c) quiescent sedimentation, (d) continuous flow sedimentation, in each case with or without chemicals, (e) septic tank, or other bacterial treatment, or (f) a combination of these latter with chemicals which may be especially called for in the case of mixed sewages; (2) the production of a satisfactorily high standard of purity in any effluents to meet the requirement of the Rivers Pollution Prevention Act, 1876, especially as regards potable waters, and those used for edible shellfish layings; also to prevent what might be considered interference with the amenities of a district, or an estate, which might involve the authority in an expensive law suit, and the payment of heavy damages, and even result in the partial reconstruction of the works; (3) the production of as little sludge as possible, and the adoption of some satisfactory means of disposal of that resulting from any artificial method followed.

As regards small installations in connection with public or private institutions, mansions, or other isolated residential property, cost is an item which calls for consideration in the majority of cases; besides which most of the above factors have to be taken into consideration.

For the reasons given, the question of cost ought, wherever possible, to occupy quite a secondary position. It is essential in the majority of cases, and more particularly in dealing with town and "mixed" sewages, that as lengthy experiments as possible should be conducted, with a view to determining the most suitable method to adopt. This may be considered an expensive preliminary, but the end will, in most instances, justify the means.

These experiments should be directed, among other things, to the ascertainment of: (1) the most satisfactory media for the contact beds or trickling filters and their depth*. This latter would be governed by the consideration whether it was proposed to deal with the tank effluents by contact or percolation; (2) the rate of air supply which it may be necessary to give them to enable the various organisms effectually to carry on their work; (3) the †most suitable rate at which the sewage should be "fed" to the sedimentation tanks, and the length of time it should be "held up"; (4) the same as regards the filters; (5) the length of the periods of "rest" to be allowed them, and their frequency, to ensure efficient æration, and to prevent the various growths to which the different filtering media are liable; and from the data thus obtained, the area of the different portions of the works which seem to be called for to carry out the process of sewage purification efficiently may be decided upon.

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* Stoddart thinks the depth of filter should not be more, or much less, than 12 feet.

† Mr. Stoddart also recently gave it as his opinion that the surface and base of the filter should be freely exposed to the air; lateral æration not being so important.

CHAPTER XLIV.

Sewage Disposal from Troops in the Field.

An important factor in the general health of troops when operating in the field is the efficient disposal of the fæces and urine, because not only is the danger from the contamination from the soil, and also the air, in the vicinity very great, but flies and other insects may be the means of contaminating food stuffs, and not infrequently becoming the media for the conveyance of the specific organisms of some infectious disease. According to Parkes, cholera, dysentery, enteric fever, and ophthalmia are transmitted by flies which have access to specifically infected excreta and secretions, especially in tropical climates. Again, what is even more serious in its effect on the health of troops when camping is the pollution of water supplies by infected excreta, which has, on so many occasions, led to virulent outbreaks of enteric fever.

The last very serious outbreak of this kind, so far as the British Army is concerned, was during the South African War, which resulted in the death of a much greater number of men than from all other causes combined. The knowledge gained from these events, coupled with the experiences of the combatants in the Russo-Japanese War, led to a very complete remodelling of the methods employed in the British Army in relation to the sanitation of troops in the field, and the study of this subject is now looked upon as incumbent on every officer and member of the British Regular and Territorial Forces to an extent which cannot be overestimated.

The Regulations and instructions in this connection are embodied in the Field Service Regulations, Part I. (operations) and Part II. (organisation and administration), issued by the command of the Army Council, by the War Office in February and April, 1909; they apply equally to the Territorial as to the Regular Arm of the Service.

General Organization of the Sanitary Service.

Under this heading, and so far as these notes are concerned, the chief duties of sanitary officers are to see to the health conditions of billets, camps, bivouacs, and pools, and also to advise regarding the purification of water for drinking purposes, latrines, and urinals, and the disposal of refuse.

The *personnel* of the sanitary service comprises:—

(a) The regimental sanitary organization of field units;

(b) The sanitary organization on the lines of communication.

The Regimental Sanitary Organization of Field Units.

Each unit is provided with a regimental sanitary detachment, drawn from the ranks of the unit staff, and partly from the ranks of the Royal Army Medical Corps.

The duties of the latter include the daily supervision of the water supply and its purification for drinking purposes by boiling, filtration, or the addition of chemicals, as may be directed, the charge of all apparatus and stores connected therewith, and the supervision of the use of disinfectants.

As regards the sanitary *personnel* of the detachment of the unit, their duties include acting as sanitary police for the prevention of soil pollution, and in detail to supervise:

(1) The preparation and care of latrines and urinals, including the filling in of the same and the marking of old sites;

(2) The systematic collection, removal, and disposal of refuse by burning or otherwise;

(3) The construction of ablution places, and the disposal of waste water;

(4) The sanitation of cooking places, horse and mule lines, and slaughtering places in the area occupied by the unit.

Sanitary Organization on the Lines of Communication.

The lines are divided into sanitary districts and posts, with a special sanitary officer who is appointed to each district, with a sanitary section as well; whilst to each post a sanitary squad is allotted. The duties of the former are analagous to those of a medical officer of health under a Public Local Authority, and include the supervision of food and water supplies, the disposal of sewage and refuse; also disinfection, and the taking of preventive measures as regards infectious disease.

The duties of a post sanitary squad are as follows:—

(1) To execute skilled work in connection with disinfection, the provision of pure water, including its

collection, distribution and storage, the construction of incinerators, etc.;

(2) To superintend conservancy or other work in connection with sanitation;

(3) To act as sanitary police;

(4) If a post has a railway station under military control to exercise sanitary supervision over the water supply to the troops passing through and over the conservancy arrangement generally.

The Sanitary Inspection Committee.

On mobilization being ordered, this committee is formed, consisting of a combatant officer as president, and a field officer, Royal Engineers and Medical Corps respectively, as members. The committee receive the instructions of the Commander-in-Chief through the Director of Medical Services. Their duties are:—(1) Generally to assist commanders of troops and the medical service in maintaining the health of the Army by co-ordinating the work of the different military branches, and the civil sanitary organization; (2) to visit and inspect stations occupied by troops; (3) to advise local authorities regarding necessary sanitary measures, and to further in every way the maintenance of satisfactory sanitary conditions, reporting to the Director of the medical and sanitary services any measures they consider necessary, but which they cannot arrange to be carried out locally; (4) to ascertain what sanitary appliances and materials of all kinds are required for the Army, and to see that an adequate reserve is maintained.

Sanitation in Camp and Bivouac.

Latrines should be constructed to seat, if possible, five per cent. of the troops, with an allowance of one yard per man. Natives should have special ones provided.

The trenches must be narrow and deep to prevent the contents being blown about. The excreta should be at once covered up with earth, at least twice daily, to prevent the possibility of spreading disease.

No one should urinate elsewhere than in the latrine trenches, or in urinal or special pits. Receptacles, such as empty biscuit tins, should be placed at convenient spots close to the tents at night, to be used as urinals, to prevent pollution of the ground. Special care should be used in selecting the position of latrines, urinals, refuse pits, cattle lines, etc. At least 100 yards should separate them from the water supply and kitchens, and they should be, if possible, to leeward. The water supply must be protected from pollution by seeing that latrines, etc., are never placed in or near gullies from which rain water or drainage or filtration may reach it. As regards disinfectants, cresol solution and chloride of lime are the most efficacious.

To use cresol, mix $1\frac{1}{2}$ ounces of cresol solution with 1 gallon of water.

In standing camps and rest camps incinerators for burning dead animals, refuse, etc., should be constructed. Where possible an improvised pail system of removal should be established.

Generally, every precaution should be taken to ensure freedom from pollution to the ground and air; and no matters should be allowed to collect which would be likely to encourage or form a breeding-ground for flies.

APPENDIX A.

Present Requirements of the Local Government Boards.

The findings of the Fifth Royal Commission, as set forth in the Fifth (1908) Report, have influenced the modification of the Board's hard and fast rules, and they now recognise the necessity of differentiating between the needs of one district as regards sewage disposal and those of another. Their previous requirements failed to make any allowance for this, and consequently what had long been considered as unnecessary work was carried out in laying down many installations, instead of attention being given to the peculiar circumstances of each case.

England and Wales.

The Local Government Board, in a communication to the writer, dated 17th March, 1910, say "that they have not issued any regulations with regard to the treatment and disposal of sewage, for the reason, amongst others, that their requirements necessarily vary with the circumstances of different places. The Board may, however, add that they consider it essential that any scheme of sewage disposal, for the execution of which it is proposed to borrow money, with their sanction, should be based on the recommendations made by the Royal Commission on Sewage Disposal in their Fifth Report; but it will be observed, in reference to that report, that the Commission do not lay down any hard and fast rule which they would regard as applicable without modification to the circumstances of every case."

Works of Sewerage.

Application for Loan.

Where the local authority contemplate borrowing money for the execution of sewerage works, the various particulars set out in the form hereunder have to be supplied to the Local Government Board.

Form I.

WORKS OF SEWERAGE.—Estimates and Details.

Name of Council . . . . :

Will any of the proposed works be outside the limits of the District of the Council, and if so; in what Parish and Sanitary District will they be situate ? . . . .

In the case of a Rural District—(*a*) *Name of Contributory Place for which the works are required* . . . .

(*b*) *If any of the works are to be executed in another Contributory Place, name of such Contributory Place* . . . .

In the case of an Urban District, state whether all the streets to be sewered are highways repairable by the inhabitants at large

. . . .

NOTE.—Estimates must be accompanied by plans and a full description of the works, and by the figures generally upon which the Scheme is based.

The following rules should be observed in the preparation of the plans :—

1. No drawings of works, other than ordnance maps or plans showing large areas, should exceed double elephant size.
2. All drawings and plans, other than ordnance maps, should preferably be made on the dull side of tracing cloth. If sun prints are furnished they should be "black lines on a white ground." Blue prints are objectionable. No tracings should be made on paper, and any drawings, etc., on paper which tears easily should be mounted on linen.
3. All plans, maps, and drawings should be (1) numbered in the top right-hand corner, (2) signed by the Engineer for the scheme, and (3) securely fastened or bound together along the left side.
4. All drawings must be fully dimensioned, with scales drawn on them, and levels shewn reduced to O.D. Plans and maps other than ordnance maps should have the north point put on them, and the boundaries of parishes and of Urban or Rural Districts should be clearly marked. Longitudinal sections should run in the same direction as the plans.
5. Places referred to in the general description should be indicated on the plans or drawings by distinctive marks for purposes of reference.

Brick Sewers.

Name of Street or Road.	Gradient.	Average Depth of Sewer.	Internal Diameter or Dimensions of Sewer.	Length in yards.	Price per lineal yard.	Amount. £	s.	d.	Remarks.
					£				

N.B.—State whether the sewers are to be constructed of common bricks, or of radiated bricks, or of rubble, concrete, or some other material. Radiated bricks should be used when they can be obtained.

Side junctions for house drains should be inserted in brick sewers at the time of construction. Junction pipes should be provided on all pipe sewers.

Forward a description of the subsoil to the extent of the greatest depth of any sewer-trench, tunnel or heading, ascertained by trial holes or by borings at certain distances.

Main sewers should, as far as practicable, be laid at such depth and with such gradients as to afford means for draining the cellars and basements of houses.

Earthenware Pipe—Sewers and Drains.

Name of Street or Road.	Gradient.	Average Depth.	Dimensions.	Length in yards.	Price per lineal yard.	Amount. £	s.	d.	Remarks
			Brought	forward	.. ..				
					£				

N.B.—Describe the pipes.

Describe the material to be used in making the joints, and the mode in which the joints are to be made good.

All sewers laid under roadways should have at least four feet clear of cover. When this is impracticable the pipes should be surrounded with six inches of concrete.

Manholes, Gullies and Ventilators.

Description of Work.	Number.	Price.	Amount.			Remarks.
			£	s.	d.	
Brought forward ..	.. ..	.. ..				
Manholes, with Moveable Covers, complete—						
Gullies, complete—						
Lampholes, complete—						
Sewer & Drain Ventilators—						
		£				

N.B.—Describe the manholes, lampholes, gullies and sewer ventilators.

OUTFALL WORKS, &c.

Description of Work.	Amount. £	s.	d.	Remarks.
Brought forward				
Particulars of Outfall Works in detail—				
„ Special Flushing Works in detail—				
„ Pumping in detail—				
„ Sewage Irrigation Works in detail—				
„ Sewer and Drain Flushing Arrangements in detail—				
Other Expenses, if any—				
Total .. .. .. £				

Date .... (*Signed*)..........................

N.B.—This form should be signed by the Engineer of the proposed works.

Scotland.

Under date April 7th, 1910, the Local Government Board, Edinburgh, informed the writer that they had issued no regulations as to sewage disposal installations, but that each application for the Board's recommendation to a loan for drainage works was considered on its merits. This Board has thus fallen into line in this respect with those for England and Wales and Ireland.

The particulars required by the Board relative to the work for the execution of which the particular authority wish to raise a loan are set out in the following Form (II.).

Form II.

DRAINAGE.

Local Government Board for Scotland.

Return by the Local Authority of......................... applying for Loan for Drainage Works.

1. By what Engineer or Surveyor are the projected drainage works designed?	....
2. Under whose management and superintendence are the works to be executed?	....
3. Are the works to be executed by contract or day's wages?	....
4. Are the works to be executed by means of the proposed Loan complete in themselves, or parts of other works?	....
5. Has any contract been entered into for the whole or any portion of the proposed works? If not, can it be shown that any such contract can be made with a responsible contractor at a cost not exceeding the Engineer's or Surveyor's estimate?	....
6. If the works have already been executed, state the date of their completion	....
7. How is the sewage ultimately treated or disposed of?	....

8. The following documents and plans should accompany the Local Authority's application for Loan :—

(*a*) Copies of all reports that have been made by the Engineer or Surveyor regarding the proposed Drainage Scheme.

(*b*) Detailed working drawings and sections showing method of construction and dimensions of work.

(*c*) Detailed working specification, giving quality and sizes of materials.

(*d*) Detailed measurement of work, giving the quantities of work of every kind in separate items.

(*e*) Detailed estimate by Engineer or Surveyor, which shall consist of the above measurement, with prices attached to each item, and the whole of these items summed up so as to give the lump estimate.

(*f*) Report by Engineer or Surveyor stating the time within which it is expected to complete the whole or any separate portion or portions.

(*g*) Reports by the Medical Officer of Health and Sanitary Inspector as to whether, in their opinion, the proposed scheme is satisfactory.

(*h*) Statement showing how the amount of the proposed Loan is made up.

Signature ....

Date.......... *Clerk.*

Ireland.

On the 8th April, 1910, the Local Government Board for Ireland informed the writer that they had not published any requirements relative to the subject of new sewage disposal installations; but where a local authority wishes to make application to the Board for sanction to a loan required for the purpose of carrying out a sewerage scheme, a very detailed Form III. or IV. has to be filled up, containing the particulars thereof and accompanied by the necessary plans and specifications. Beyond these, the Board have no special forms to be filled up as regards sewage disposal works.

The particulars to be furnished in respect of the scheme vary according to whether the works are to be carried out by an urban or rural district council.

The particulars furnished have to be signed by the engineer under whom the works will be executed, or by the clerk to the council, depending on the nature of the information supplied on the form in question.

FORM III.

....*Urban District Council.*

41 & 42 Vic., cap. 52. Public Health (Ireland) Act, 1878, Sections 237 and 238.	APPLICATION FOR SANCTION OF LOCAL GOVERNMENT BOARD TO LOAN. No expenditure should be incurred in respect of the works until the Council shall have been informed that the loan has been authorised by the Lords Commissioners of His Majesty's Treasury.
I. Amount of Loan.	£
II. From whom the Council propose to obtain the Loan.	
III. Purpose to which the Loan is to be applied.	
IV. Period for which the money is proposed to be borrowed.	
V. Valuation of the Urban District.	Houses, £ Lands, £ Half Annual Rents, £ Government Property, £ £ realizable by a rate of 1s. in the £, exclusive of the Government contributions in lieu of rates.
VI. Poundage leviable on the district in the present year.	(see table below)

Poundage	Poor Rate for the year	Town Improvement Rate	Any other Rates (naming them) for........	for........	for........	Total	
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	
Produce							

VII. Outstanding Loans under the Public Health Act and "Sanitary Acts" (as interpreted in section 2), chargeable upon the district.

Purpose	Amount of loan	Date	Number of years	Rate of Interest	Principal paid off			Principal outstanding		
	£				£	s.	d.	£	s.	d.

VIII. Any other Loans or mortgage debts.

IX. Whether it is necessary to acquire any lands* for the proposed works; if so, whether it is proposed to obtain them by agreement† or compulsorily.

Purpose	Amount of loan	Date	Number of years	Rate of Interest	Principal paid off			Principal outstanding		
	£				£	s.	d.	£	s.	d.

* NOTE.—The word "lands" includes messuages, buildings, lands, easements and hereditaments of any kind (Sec. 2), and (for the purpose of a water supply), any land covered with water or any water or right to take or convey water (Secs. 202 and 203).

† If "by agreement" the acquisition of the lands must be definitely arranged for before the loan can be sanctioned.

Note A.—Ordnance Maps on a scale of not more than 220 feet to one inch are published of many towns in Ireland, and others are being issued from time to time.

Note B.—Refers to Water Supply.

Note C.—If any portion of the work is to be without the district, the provisions of Sections 35, 36, and 37 of the Public Health (Ireland) Act, 1878, must be complied with.

Full plans, estimate, and specification of all proposed structural works suitable for attachment to a contract, should be forwarded with application, and each plan and document should be dated and authenticated by the signature of the engineer who prepared them. If the loan be sanctioned, certified copies of these documents, similarly authenticated, will be required to be deposited with the Local Government Board before the loan is recommended for issue.

Where the Works are for SEWERAGE, the following particulars will be necessary :—

I. A map of the district to be sewered on a scale of not more than 220 feet to one inch, showing the dimensions and course of all proposed sewers, positions of manholes, ventilators, and gully-traps, the inclination of each sewer or pipe sewer from point to point, and the heights at each of such points of the surface of the streets, and of the lowest interior part of the sewer or pipe sewer, both expressed in feet and decimals over a fixed common reference datum point, referred to Ordnance Datum.

II. The course, dimensions, and levels of existing sewers, and information as to how they are to be dealt with.

III. In case of a discharge into tidal waters being proposed, a map of the district adjoining the outfall, corrected, to date, as to new buildings. The lines and levels of High and Low Water, Springs and Neaps, should be shown, and any information available as to outside soundings and currents should be given.

N.B.—The consent of the Board of Trade must be obtained to the execution of any works below High Water Mark.

IV. A statement of the area contributing to each outfall, with its population.

V. Any special duty likely to be thrown on the sewers from factories.

VI. If there is a probability of a neighbouring district seeking to use the proposed sewers, full particulars as to area, population, etc., of such district to be given.

VII. Are any portions of the proposed works to be situate outside the district?

VIII. In what manner and where the sewage is to be disposed of, having regard to the provisions of the 19th Section of the Public Health Act, 1878, which forbids any Sanitary Authority to "make or use any sewer, drain, or "outfall for the purpose of conveying "sewage or filthy water into any "natural stream, or watercourse, or "into any canal, pond or lake until "such sewage or filthy water is freed "from all excrementitious or other foul "or noxious matter, such as would "affect or deteriorate the purity and "quality of the water in such stream "or watercourse, or in such canal, "pond, or lake;" also observing the provisions of the Rivers Pollution Prevention Act, 1876, 39 and 40 Vic., cap. 75.

Given under my hand this day of 19

Countersigned,

....
Chairman of the Urban District Council.

....
Clerk.

....
Urban District Council.

Suggestions as to the Preparation of Plans, etc.

Elevations, plans, and sections of structural works should be on a scale of not more than eight feet to one inch. The scale of the general plans should be the same as the horizontal scale of the sections, and the vertical scale of sections of sewers should be of not more than ten feet to one inch. Copies of drawings and plans on tracing linen are preferable to copies on paper. When it is practicable, plans and tracings are much more conveniently transmitted folded than in a roll.

Specifications should contain clauses as to payments and retention money; term of completion of work; penalty for default; extras and alterations (*orders for which should, in all cases, be specified as having to be made by the Council*); sub-letting; annulling of contract for insufficient progress; responsibility of contractor for damages by trespass or otherwise; term of maintenance; and settlement of disputes.

In the case of laying pipes or sewers, inspection and testing previous to the work being covered up should be provided for.

In the case of cast-iron pipes under pressure the specification should require that they should be actually tested. The weight of pipes is best specified by stating the weight of a pipe-length (in the work) for each size.

Cement should be subject to specified tests for strength, fineness, and weight.

The joints of pipe sewers should be made with cement mortar, and the specification should provide for thoroughly clearing the pipes after jointing.

FORM IV.

....*Rural District Council.*

41 & 42 Vic., cap. 52, Public Health (Ireland) Act, 1878, Sections 237 & 238.	APPLICATION FOR SANCTION OF LOCAL GOVERNMENT BOARD TO LOAN. No expenditure should be incurred in respect of the works until the District Council shall have been informed that the loan has been authorised by the Lords Commissioners of His Majesty's Treasury.
I. Amount of Loan. II. From whom the Council propose to obtain the Loan. III. Purpose to which the Loan is to be applied. IV. Period for which the money is proposed to be borrowed. V. (*a*) Contributory district, being the area of charge on which the loan is to be secured. (*b*) Date of Sealed Order of Local Government Board determining the area. (*c*) Annual assessable value of the area.	£

VI. Poundage leviable on the contributory district in the present year, and if it varies on different portions of the district, then for each such portion.

Portion of area of charge	Poor Rate for the year	Any other rates (naming them)			Total
	s. d.	s. d.	s. d.	s. d.	s. d.

VII. Outstanding Loans under the Public Health Act and "Sanitary Acts" (as interpreted in Section 2), and the Labourers' (Ireland) Acts, chargeable upon the district or any portions thereof.

Purpose	Amount of loan	Date	Number of years	Rate of Interest	Principal paid off			Principal outstanding		
	£				£	s.	d.	£	s.	d.

VIII. Any other Loans or mortgage debts.

IX. Whether it is necessary to acquire any lands* for the proposed works; if so, whether it is proposed to obtain them by agreement† or compulsorily.

Purpose	Amount of loan	Date	Number of years	Rate of Interest	Principal paid off			Principal outstanding		
	£				£	s.	d.	£	s.	d.

* Note.—The word "lands" includes messuages, buildings, lands, easements and hereditaments of any kind (Sec. 2), and (for the purpose of a water supply), any land covered with water or any water or right to take or convey water (Secs. 202 and 203).

† If "by agreement" the acquisition of the lands must be definitely arranged for before the loan can be sanctioned.

Note A.—Ordnance Maps on a scale of not more than 220 feet to one inch are published of many Towns in Ireland, and others are being issued from time to time.

Full plans, estimate, and specification of all proposed structural works suitable for attachment to a contract, should be forwarded with the application, and each plan and document should be dated and authenticated by the signature of the engineer who prepared them. If the loan be sanctioned, certified copies of these documents, similarly authenticated, will be required to be deposited with the Local Government Board before the loan is recommended for issue.

Where the Works are for SEWERAGE, the following particulars will be necessary:—

I. A map of the district to be sewered on a scale of not more than 220 feet to one inch, showing the dimensions and course of all proposed sewers, positions of manholes, ventilators, and gully-traps, the inclination of each sewer or pipe sewer from point to point, and the heights at each of such points of the surface of the streets, and of the lowest interior part of the sewer or pipe sewer, both expressed in feet and decimals over a fixed common reference datum point, referred to Ordnance Datum.

II. The course, dimensions, and levels of existing sewers, and information as to how they are to be dealt with.

III. In case of a discharge into tidal waters being proposed, a map of the district adjoining the outfall, corrected, to date, as to new buildings. The lines and levels of High and Low Water, Springs and Neaps, should be shown, and any information available as to outside soundings and currents should be given.

N.B.—The consent of the Board of Trade must be obtained to the execution of any works below High Water Mark.

IV. A statement of the area contributing to each outfall, with its population.

V. Any special duty likely to be thrown on the sewers from factories.

VI. If there is a probability of a neighbouring district seeking to use the proposed sewers, full particulars as to area, population, etc., of such district to be given.

VII. Are any portions of the proposed works to be situate outside the district?

VIII. In what manner and where the sewage is to be disposed of, having regard to the provisions of the 19th Section of the Public Health Act, 1878, which forbids any Sanitary Authority to "make or use any sewer, drain, or "outfall for the purpose of conveying "sewage or filthy water into any "natural stream, or watercourse, or "into any canal, pond or lake until "such sewage or filthy water is freed "from all excrementitious or other "foul or noxious matter, such as "would affect or deteriorate the purity "and quality of the water in such "stream or watercourse, or in such "canal, pond, or lake"; also observing the provisions of the Rivers Pollution Prevention Act, 1876, 39 and 40 Vic., cap. 75.

Given under my hand this day of 19

Countersigned,

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Chairman of the Rural District Council.

....

Clerk.

....

Rural District Council.

Suggestions as to the Preparation of Plans, etc.

Elevations, plans, and sections of structural works should be on a scale of not more than eight feet to one inch. The scale of the general plans should be the same as the horizontal scale of the sections, and the vertical scale of sections of sewers should be of not more than ten feet to one inch. Copies of drawings and plans on tracing linen are preferable to copies on paper. When it is practicable, plans and tracings are much more conveniently transmitted folded than in a roll.

Specifications should contain clauses as to payments and retention money; term of completion of work; penalty for default; extras and alterations (*orders for which should, in all cases, be specified to be made by the Sanitary Authority*); sub-letting; annulling of contract for insufficient progress; responsibility of contractor for damages by trespass or otherwise; term of maintenance; and settlement of disputes.

In the case of laying pipes or sewers, inspection and testing previous to the work being covered up should be provided for.

In the case of cast-iron pipes under pressure, the specification should require that they should be actually tested. The weight of pipes is best specified by stating the weight of a pipe-length (in the work) for each size.

Cement should be subject to specified tests for strength, fineness, and weight.

The joints of pipe sewers should be made with cement mortar, and the specification should provide for thoroughly clearing the pipes after jointing.

APPENDIX B.

Sewage, Drainage, and Sewage Disposal Legislation. (England and Wales and Ireland.)

The Acts regulating this part of our subject are practically identical in their wording, as regards their principal provisions, though passed as separate measures. The Public Health Act, 1875, is the parent Act as regards England and Wales; the Public Health (Ireland) Act, 1878, occupies a similar position in Irish legislation.

More recent measures regulating the administration of the law on this subject are contained in the same Acts, with the necessary alterations. Such are the Public Health Acts Amendment Acts of 1890 and 1907, both of which are "*adoptive*" by the local sanitary authority, and not, like the parent Acts of 1875 and 1878, compulsory. In these notes the sections of the 1875 and 1878 Acts respectively will be indicated at the beginning of each.

Some Definitions.

These are contained in Section 4 of the 1875 Act, and Section 2 of that of 1878.

The following may be useful:—

"**Person**" includes any body of persons, whether corporate or incorporate.

"**Sanitary Authority**" means urban or rural sanitary authority, as by this Act defined, as the case may be (now the town, urban, or rural district council).

By the Local Government (Ireland) Act, 1898, Section 21, Sub-section 1, it is enacted that all urban sanitary authorities shall be called urban district councils, and their districts urban districts; (2) that every rural sanitary district shall have a rural district council, whose district shall be a rural district, to whom the business of the rural sanitary authority in the district shall be transferred.

"**Borough**" means any place for the time being subject to the Municipal Corporations Acts, 1832, or Ireland Act, 1840, and amending Acts.

"**Lands and Premises**" include messuages, buildings, lands, easements, and hereditaments of any tenure.

"**Owner**" means the person for the time being receiving the rack rent of the lands or premises in connection with which the word is used, whether on his own account or as agent or trustee for any other person, or who would so receive the same if such lands or premises were let at a rack rent (as in the case of unoccupied property).

"**Rackrent**" means rent which is not less than two-thirds of the full net annual value of the property out of which the rent arises (in Ireland, as ascertained under the Acts relating to the valuation of rateable property). The 1875 Act further enacts as regards England and Wales that the "full net annual value" shall "be taken to be the rent at which the property might reasonably be expected to let from year to year, free from all usual tenants' rates and taxes and tithe commutation rent charge (if any), and deducting therefrom the probable average annual cost of the repairs, insurance, and other expenses (if any) necessary to maintain the same in a state to command such rent.

"**Drain**"* means "any drain of and used for the drainage of one building only, or of premises within the same curtelage and made merely for the purpose of communicating therefrom with a cesspool, or other like receptacle for drainage, or with a sewer into which the drainage of two or more buildings, or premises occupied by different persons, is conveyed."

"**Sewer**"* includes sewers and drains of every description except drains to which the word "*drain*" interpreted as aforesaid applies, and except drains vested in, or under, the control of any authority having the management of roads, and not being a sanitary authority under this Act.†

"**House**" includes schools, and also factories and other buildings in which persons are employed. ("Whatever their number may be," is added in the 1878 (Ireland) Act.)

"**Factories,**" which expression also includes workshops and work-places, which words have very wide meanings, are now subject to the provisions of the Factory and Workshop Act, 1901, which applies to the United Kingdom, with a

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* See "Some Notes on the Law of Drains and Sewers in the United Kingdom," p. 298.

† See also Section 19 of the Public Health Acts Amendment Act, 1890, p. 252.

few essential modifications. Those applicable to Ireland are set out in Section 160 of the Act, and Sections 149 and 159 (Scotland).

Sundry Provisions as to Sewers and Drains.

Sections 13 and 14 (E. and W.), 15 and 16 (I.).—With the exception of sewers made by a person or company for profit, or under Act of Parliament for draining, preserving, or improving land; or under the control of Commissioners of Sewers appointed by the Crown (such as Commissioners for certain drainage "levels," for the preservation of land from floods), *all* sewers shall vest in the sanitary authority of the district, who may purchase or otherwise acquire same, together with all buildings, works, material, etc., belonging thereto.

Section 15 (E. and W.), 17 (I.).—The authority shall keep all such sewers in repair, and shall cause others to be made for the effectual drainage of the district.

Section 16 (E. and W.), 18 (I.), authorises the authority to lay sewers in roads, etc., and under pavements, carriage-ways, etc., and, subject to giving reasonable notice to owner or occupier, through or under any lands in their districts, and also execute works for the outfall or distribution of sewage outside their district, subject to the provisions of Sections 32-34 (E. and W.), or Sections 35-37 (I.), which deal with the construction and extension of sewage works outside the district of a local authority.*

Sections 19-22 (E. and W.), 21-3-4 (I.).—Local authorities must properly cleanse, empty, ventilate, repair, or construct sewers, to which owners and occupiers of property in their districts may connect their drains, subject to the inspection and control of the local authority (by their surveyor). If without the district, arrangements may be come to between the local authority of the district owning the sewers and the persons concerned, subject to settlement by arbitration in case of dispute. Maximum penalty, in default, £20.

Sections 23-5 (E. and W.), 25-7 (I.).—Local sanitary authorities are empowered to enforce the efficient drainage of all houses, within a reasonable time after written notice, with suitable and approved material, by emptying such drains into a sewer if not more than 100 feet away; otherwise, into a cesspool or other place, at the discretion of the

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* See p. 243

authority. In default, the latter may execute the works, the owner being liable for the summary payment of expenses; or, if a private improvement rate is in force within the district, thereby.*

The like provisions prevail where the authority decide to construct a special sewer for the drainage of two or more houses.

Under a maximum penalty of £50, no house in an urban district is to be built unless provided with efficient drains, emptying as directed by the local authority.

In England and Wales no house may be newly-erected over any urban authority's sewer (1875 Act, Sec. 26).

"Nuisances" as regards Drains, etc.

Any privy, urinal, cesspool, or drain so foul, or in such a state as to be a nuisance or injurious to health, shall be deemed to be a nuisance, liable to be dealt with summarily, under the Acts (Secs. 91 (E. and W.), 107 (I.)).

Information as to such nuisance may be given to the local authority by any two inhabitant householders, any of their officers, any person aggrieved thereby, any police officer, or the relieving officer (Secs. 93 (E. and W.), 109 (I.)).

If satisfied of the existence of a nuisance, the local authority must serve notice requiring abatement. If caused from the want, or defective construction, of any structural convenience, or where there is no occupier of the premises, notice must be served on the owner; otherwise on the defaulter, or the authority, if not caused by owner or occupier.

If two or more persons are in default proceedings in a court of summary jurisdiction may be taken against any one or more (Secs. 255 (E. and W.), 253 (I.)).

Defaulting Authority.

On complaint to the Local Government Board for England, Wales, or Ireland as the case may be, that default has been made by a local authority in providing their district with sufficient sewers, or in the maintenance of existing ones, the Board, if satisfied after inquiry of such default, shall make an Order for the performance of their duty in the matter of such complaint within a time fixed therein. In default, such Order may be enforced by writ of mandamus, or the Board may appoint some person to perform such

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* See p. 251.

duty, and shall by order direct the expenses of performing the work, together with a reasonable remuneration to the person appointed for superintending same and costs to be paid by the defaulting authority (Secs. 299 and 300 (E. and W.), 15, Public Health (Ireland) Act (1896)); no provision being made in the 1878 Act.

Disposal of Sewage, and Purchase of Lands Therefor.

Sections 27-31 (E. and W.), 30-34 (I.).

With regard to the treatment and disposal of sewage, and the acquisition of land for the purpose of constructing works for that purpose, there are certain provisions of the Public Health Acts which deal specially with the subject.*

Sections 27 to 31 of the 1875 Act bear upon the purchase of land for the purpose within the district of a local authority in England and Wales. As regards Ireland, these same provisions are contained in Sections 30 to 34 of the Public Health (Ireland) Act, 1878.

The provisions are to the following effect:—

For the purpose of receiving, storing, disinfecting, distributing, or otherwise disposing of sewage, any local authority may:—(1) Construct any works within or without their district (subject in the latter case to the terms of Sections 32 to 34 of the 1875, and 35-37 of the 1878 (Ireland) Acts), and contract for the execution and costs thereof.

(2) Contract for the use of, purchase, or lease of any land, building, engines, materials, or apparatus either within or without their district; and

(3) Contract to supply for any period not exceeding twenty-five years any person with sewage.

In carrying these provisions into effect no nuisance must be created.

The local authorities of adjoining districts may, subject to the sanction of the Local Government Board, agree to the communication of their sewers, any dispute as to terms to be settled by the Board. Storm water shall, as far as practicable, be prevented from entering the sewers of the owning authority, without whose sanction no sewage from other districts may be admitted thereto.

Land appropriated to sewage purposes may be dealt with otherwise, either by letting on lease for a period not exceed-

* See also Application of the Lands Clauses Acts, p. 306.

ing twenty-one years for agricultural purposes, or by contracting with some person to take the whole or a part of the produce of such land, or by farming same, and disposing of the produce; in any case, steps must be taken to prevent nuisance.

The authority may contribute to the expenses of any person with whom they agree to supply sewage in connection therewith, and may become shareholders in any company for the same purpose.

The making of works of distribution and service for the supply of sewage to lands for agricultural purposes shall be deemed an "improvement of land" under the Improvement of Land Act, 1864, and its provisions shall apply accordingly.

By Section 17 (E. and W.), 19 (I.), "nothing in the Act shall authorise any sanitary authority to make or use any sewer, drain, or outfall for the purpose of conveying sewage or filthy water into any natural stream or watercourse, or into any canal, pond, or lake, until such sewage or filthy water *is freed from all excrementitious or other foul or noxious matter*, such as would affect or deteriorate the purity and quality of the water in such stream or watercourse, or in such canal, pond, or lake."

(This is an important provision in connection with our subject, and should be taken in conjunction with the Rivers Pollution Prevention Act, 1876, Sec. 3.)*

As to Sewage Works Outside District.

Under Sctions 28 of the 1875, and 31 of the 1878 (Ireland) Acts, as referred to above, a local sanitary authority may construct or extend any sewer or other work for sewage purposes into the district of a neighbouring authority.

Sections 32 to 34 of the 1875 Act, and 35 to 37 of the 1878 Act, regulate these powers. Three months' notice, at least, has to be given by advertising a description of the work in one or more of the newspapers circulating within the district where the work is to be carried out, stating its intended termini, and the names of the parishes (town-lands, Irish Act, Sec. 35), roads and streets, and other lands (if any) through, across, under, or on which the work is to be made, mentioning where a plan may be seen at all reasonable hours.

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* See p. 292.

The owners or reputed owners, lessees or reputed lessees, and occupiers of such lands, the sanitary authority of the district, all persons having the care of such roads or streets, and (in Ireland) the secretary of the grand jury must be served with a copy of such notice.

Any of the above persons or authorities may object to the proposed works. If so, written notice must be given to the sanitary authority proposing to carry out the work, and, unless such objection is withdrawn, the work shall not be commenced without the sanction of the Local Government Board, after an inquiry by their inspector on the spot. An inquiry may also be made by the Board, on the application of the authority, when objectors may be heard; and, on receiving the report of their inspector, the Board may make an order on such terms as they may decide.

Regulations as to the Purchase of Land.

These provisions embody the Lands Clauses Consolidation Act, 1845, except those relating to access to the Special Act, and except Section 127 of the 1845 Act.

For the purpose of the acquisition of lands for sewerage works, or otherwise for the disposal of sewage, the authority proposing to carry out the same must, if it is intended to borrow money for the purpose of paying for their execution, apply to the Local Government Board in London or Dublin for sanction of the proposed outlay. The form required is set out elsewhere, and must be signed by the surveyor or engineer under whom the work is to be executed, and by the clerk to the authority.

Special provisions regulate the acquisition of the necessary land, where it is proposed to proceed otherwise than by agreement. Sections 175 to 178 of the Public Health (England and Wales) Act, 1875, and Sections 202-204 (inclusive) of the 1878 (Ireland) Act regulate the purchase; and with them the Lands Clauses Consolidation Acts, 1845, 1860, 1869, and 1883, are incorporated, as well as the provisions of the special Act, if any. Section 127 of the 1845 Act is excluded. This refers to the sale of lands which are found not to be wanted for the work, and which, by this section, have to be sold within ten years after the expiration of the time limited by the special Act for their completion, failing which superfluous land vests in the owners of that adjoining.*

* See the Lands Clauses Act, 1845, p. 306.

A good deal of circumlocution is called for in reference to the giving of public notice and the service of notices on owners, lessees, and tenants of the land and other property to be acquired, and similarly on those persons reputed to be similarly interested. Newspaper notices have to appear at least once in each of three consecutive weeks in the month of November. The newspaper or newspapers used must circulate in the particular district. The advertisement should give brief details of the purposes in respect of which it is proposed to take the land, otherwise than by agreement, and should state also the area and where a plan of the proposed undertaking can be seen.

The owners, and other interested persons, must each be served with a notice* in the month of December, stating what it is proposed to take, and requesting a reply as to whether the party is agreeable or not, or whether he is neutral in the matter.

Not less than fourteen days after this latter provision has been fulfilled, the authority may present a petition to the Local Government Board, giving all the above particulars, and also the names of the persons interested in the lands, praying that the powers of the Lands Clauses Consolidation Acts may be put into operation; following which the Board may either refuse to sanction the same, or direct a local inquiry; and until this has taken place the Board may not make a Provisional Order affecting the lands in question, without the consent of the parties interested.

When the inquiry is completed, and the Board's inspector has duly reported, the latter may either dismiss the appeal, or give their sanction thereto, with or without such modifications as may seem desirable, and forthwith it shall be the duty of the sanitary authority in question to serve a copy of any Order which may be made on the persons concerned in the lands proposed to be compulsorily acquired. The notices required to be given in November and December may be given in the months of September and October, or of October and November, in which case, however, an inquiry preliminary to the Provisional Order to which such notices refer shall not be held until the expiration of one month from the last day of the second of the two months in which the notices were given; and any notices or orders by this section required to be served on a number of persons,

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* As regards the Service of Notices, see p. 248.

having a joint right over such lands, will be satisfied by service on any three or more of such persons on behalf of the others.

The inspectors of the Local Government Board have similar powers in relation to calling upon witnesses, the production of papers and accounts, as if they were Poor Law inspectors under the Poor Law Acts (Secs. 296 (E. and W.), 213 (I.)). As regards the Board's Provisional Orders, before making such, the Board may give consideration to the objections of any interested persons, and, if necessary, give them facilities for being heard, and, in order that it shall have legal effect, the Board must submit it for confirmation by Parliament. If a petition is presented against the Bill whilst before Parliament, it may be referred to a Parliamentary Select Committee. The making of a Provisional Order shall be prima facie evidence that all the requirements of this Act in relation to the procedure, service of notices, etc., have been complied with. The costs of the sanitary authority incurred in connection with the various matters dealt with under the Provisional Order may be made part of a loan sanctioned by the Board (Secs. 297-8 (E. and W.), 214-5 (I.)).

Arbitrations under the Public Health Act, 1875, or the Public Health (Ireland) Act, 1878.

Under Sections 197-81 (E. and W.), 216-8 (I.), if the amount of compensation to be payable in respect of the acquisition of land for the purposes of sewage disposal works cannot be settled except by arbitration, and the provisions of this Act as to its determination are brought into operation, which they will be unless the provisions of other Acts are involved, then unless both parties concur in the appointment of a single arbitrator, each party shall appoint an arbitrator, to whom the matter shall be referred.

The regulations as to arbitrations provide for the following matters:—

The appointment of an arbitrator or arbitrators shall be under seal where the persons appointing are a sanitary authority or a corporation aggregate. Otherwise such appointment shall be under hand. It shall be irrevocable without the consent of both parties, and even the death of either party shall not revoke the same.

Failure by one party to appoint an arbitrator will enable the other one to act alone on behalf of both parties.

Should either arbitrator die, become incapable, or refuse to act, the party appointing such arbitrator may appoint another in his place, and if seven days elapse without his doing so, the remaining arbitrator may proceed *ex parte*.

If, before making his award, a single arbitrator dies, or becomes incapable to act, or fails to make his award within twenty-one days after his appointment, or within such extended time (if any) as he may have fixed for that purpose, the whole procedure shall commence afresh.

In the event of an arbitrator being appointed by each party, they shall appoint an umpire to act in the event of their differing as to the amount of compensation payable, or on other matters relevant to the arbitration. If the umpire dies, or becomes incapable, or refuses to act,* the arbitrators shall forthwith appoint another in his place, or the Board will do so on the application of either party thereto if default is made by the arbitrators for the space of seven days. The appointment of an umpire must be in writing, and the matter automatically reverts to him, if the arbitrators fail to make their award in writing within twenty-one days after the day on which the last of them was appointed, or such extended time, if any, as they may appoint. This extended time shall not exceed two months from the date of the reference.

Declaration of Arbitrators or Umpire.

Before entering on a reference under this Act, these persons, or either of them, shall make and subscribe the following declaration before a Justice of the Peace:—

I (A. B.) do solemnly and sincerely declare that I will faithfully and honestly, and with the best of my skill and ability, hear and determine the matters referred to me under the Public Health Act, 1875 (or the Public Health (Ireland) Act, 1878).

(Signed) A. B.

This declaration has to be annexed to the award when made, and wilful acts contrary to it will render arbitrator or umpire, as the case may be, guilty of a misdemeanour.

Arbitrators or umpire may call for the production of such documents as may be in the possession or power of either party, and which they may consider essential to the satisfactory determination of the matters referred, and may

* This addition was made by Section 24 of the Public Health (Ireland) Act, 1896, but formed part of the 1875 Act, Section 180 (7).

examine the parties or their witnesses on oath. The cost of the reference and incidental thereto shall be in the determination of the arbitrator, arbitrators, or umpire, as the case may be.

The award shall be final and binding on all parties to the reference, but any submission to arbitration may be made a rule of any of the superior courts, on the application of any party thereto. If the claim of either party amounts to less than £20, it may, if either party so wish, be determined by a court of summary jurisdiction (police-court), but the court may, if it thinks fit, require the work in respect of which the claim of the sanitary authority is made, and the particulars thereof to be reported on by any competent surveyor, not being the surveyor to such authority, and the court may determine the amount and cost so incurred, and as to their payment.

Entry on Lands.

Under Sections 305 (E. and W.), 271 (I.), for the purpose of surveying and levelling, the preparation of plans, taking borings, and other purposes, the local authority have power to enter upon the lands and other property which it is proposed to acquire; Section 271 provides for this, and enacts that a written notice shall be given to the owner or occupier of the property in question that the local authority intend to apply to the police-court for an order authorising entrance for examination, survey, preparation of plans, etc., as may be needed; in default, a penalty may be imposed. The hours of such entry, save in cases of emergency, are from 9 a.m.—6 p.m. In the latter case no previous notice is necessary.

Where any damage is occasioned, either by entry on the lands or premises, or in the subsequent work, the local authority shall be liable to make compensation, the amount to be settled either by agreement, or, in cases of dispute, by arbitration, in the manner above described, or, if the amount claimed does not exceed £20, by the local police-court.

Service of Notices.

Under Sections 266 and 267 of the Public Health Acts (England and Wales), 1875, and (Ireland), 1878, the method in connection with the service of notices is set forth. Any such notice may be addressed to the owner or occupier of the lands or premises in question by the description of the "owner," or "occupier," of the premises (naming them) in respect of which the notice is given. Any notice may be served by delivering it at the residence of the person to whom addressed; if the premises are occupied, by delivering the same, or a true copy, to some person thereon; if unoccupied, by affixing the notice in a conspicuous part thereof. A notice may also be served by prepaid letter, and in that case it shall be deemed to have been served at the time when the letter containing the same would be delivered in the ordinary course of post. To prove such service it will be only necessary to prove that the notice was properly addressed and posted. All notices, orders, and other such documents may be wholly or partly in writing or print; and where required to be authenticated by the local authority, it will be sufficient for their clerk, surveyor, or sanitary inspector to sign the same.

As to Contracts.

This matter is dealt with under Sections 173 and 174 of the 1875 Act, and 200 and 201 of the Irish Act of 1878.

The following regulations apply:—

(1) Contracts exceeding fifty pounds to be in writing and under the authority's seal.

(2) A contract shall specify the work, materials, or things in question, the price and the time or times within which the contract is to be executed, and also some monetary penalty in case of failure duly to perform the terms of the contract.

(3) Prior to the contract, the sanitary authority must obtain from a competent person a written estimate of probable cost of executing the work, and of the annual cost of repairs; also a report as to whether it will be better to contract for the work only, or also for its repair during a term of years.

(4) Where the contract is £100 or more in value the authority must invite tenders by advertisement or other public notice, and require also sufficient security for the due execution thereof.

(5) Every contract so entered into shall be binding on the sanitary authority, and on the other parties thereto, and their successors, executors, administrators, and assigns: provided that the authority may compound with the other party in respect to the penalty incurred where there is non-performance of the particular contract.

These provisions apply to any sanitary authority in Ireland. but as regards England and Wales they apply only to urban districts; by Section 276 of the 1875 Act, however, the Local Government Board may, on the application of a rural authority, or of persons rated to the relief of the poor to the extent of at least one-tenth of the net rateable value, either of the particular district, or any contributory place therein, invest such rural authority with urban powers.

Works for sewerage, or of sewage treatment and disposal, may be undertaken in respect of any "contributory" place within a rural district, and in such case the expenses will be a charge thereon.

As regards sewerage works in any contributory place, the expenses incurred thereby shall be considered "special" expenses, and shall be a special charge on such special drainage district.

Joint Sewerage Works.

In some cases, either with a view to minimising the burdens on the local rates, or because the circumstances of the locality seem to suggest its advisability, two or more local sanitary authorities (urban or rural) may agree together to execute works for joint sewerage purposes, making such contribution either to the total cost, or to the annual upkeep, as may be decided upon, and in proportion to the benefit derived by their respective districts, or any part thereof (Secs. 279 and 285, 1875 Act; Public Health (Ireland) Act, 1896, Sec. 2).

Such a union of districts usually takes place as regards rural areas; and the local authorities in question must apply to the Local Government Board, in London or Dublin (as the case may be).

Joint sewerage boards may borrow on the credit of sewage land and plant from the Public Works Loan Commissioners, in England and Wales (Sec. 244), and the Commissioners of Public Works in Ireland (Sec. 247 (I.)). See also Forms I., III., and IV.*

Loans and Borrowing Powers.

Any local authority possessed of any lands, works, or other property for the purposes of sewage disposal may borrow money on the credit of such sewage land and plant.

Where the sums borrowed do not exceed three-fourths of the purchase money of such lands it is enacted that such powers shall be distinct from, and in addition to the general borrowing powers conferred by this Act, among which it is

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* See pp. 222-236.

provided that money shall not be borrowed except for permanent works, but in no case for more than sixty years (Secs. 233-5 (E. and W.), 238-40 (I.)), and see Form 1.*

Money may be borrowed from the Public Works Loan Commissioners, if they see fit on the application of any local authority, on the security of any fund or rate (Sec. 242 (E. and W.)).

The Public Health (Ireland) Act, 1878, has no section similar to this.

On the application of any local authority, and on the recommendation of the Local Government Board, the Public Works Loan Commissioners may make any loan to such authority, on the security of any fund or rate, for not more than fifty years; its duration being determined by the Board having "regard to the probable duration and continuing utility of the works in respect of which the same is required."

The words in the inverted commas are in the 1875 Act only. As regards Ireland, the consent of the Treasury is necessary.

The loan may be for works already completed or yet to be executed (Secs. 243 (E. and W.), 246 (I.)).

Private Improvement Expenses.

By Sections 213-5 (E. and W.), 229-31 (I.), rates *may* be levied on the occupier of premises in respect of which the local urban sanitary authority have carried out works (Private Improvement Rates), by means of which the expenses incurred, plus five per cent. per annum, will be repaid within a period not exceeding thirty years. While the premises are unoccupied, the rate will be payable by the owner, who, if the premises are let, will have to allow the tenant to deduct three-fourths of the same if the latter holds at a rack rent.†

As regards rural districts, Sections 232 (E. and W.), and 4 of the Public Health (Ireland) Act, 1896, provide for the making and levying of a private improvement rate by a rural council on the same lines as an urban authority.

A private improvement rate may be redeemed at any time before the expiration of the period for which it was made, by the owner or occupier of the premises in question paying the amount still due.

It is not compulsory on any authority to make and levy a private improvement rate.

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* See p. 222. † See p. 239.

APPENDIX C.

The Public Health Acts Amendment Act, 1890

(England, Wales, and Ireland).

This Act was passed to amend the Public Health Acts, and is included with them under that title. It is only an "adoptive" measure.

Part III. is the only one which concerns our subject, and contains its Sanitary Provisions. Section 3 relates to the procedure for adoption by the local council.

By Section 16, injurious matter must not be suffered to be thrown into any sewer of a local authority, or any drain communicating therewith. The maximum penalties are £10, and a daily one of 20s. for each day during the continuance of the offence after conviction.

Under penalties not exceeding £10 and £5 per day, the following must not be turned into the local authority's sewers, or any drain connected with it, chemical refuse, waste, steam, condensing or heated water, or other liquid (such water or other liquid being of a higher temperature than 110° Fahr.), which, either alone or in combination with the sewage, may cause a nuisance, or is dangerous or injurious to health.

No liability is incurred until the local authority have given notice of the terms of this section, and for seven days from its service (Sec. 17).

The owner or occupier of any premises the drains from which may communicate with any council sewer may request the authority to make such communication on the payment in advance of the cost, which shall be estimated by the council's surveyor. In case the owner or occupier is dissatisfied with such estimate, he may have it determined by a court of summary jurisdiction, if under fifty pounds; if above that amount, by arbitration as provided by the Public Health Acts (Sec. 18).

The next section (19) is one which has caused much litigation in districts where put in operation, due to the uncertainties which it has caused in the interpretation of drainage law. It enacts that:—"Where two or more houses belonging to *different* owners are connected with a public sewer by a *single private drain*, an application may be made under Section 41 of the Public Health Act, 1875 (Section 51 of the Irish Act of 1878) (relating to complaints as to nuisances from drains), and the local authority may recover any expenses incurred by them in executing any works under the powers conferred on them by that section from the owners of the houses in such shares and proportions as shall be settled by their surveyor, or (in case of dispute) by a court of summary jurisdiction."

Such expenses may be recovered summarily, or declared private improvement expenses under the Public Health Acts (Secs. 213-5 (E. and W.), 1875, 229-31 (I.), 1878).

"Drain" for the purposes of this section "includes a drain used for the drainage of *more than one building*."

All sanitary conveniences used in common and their approaches, which, in the opinion of the sanitary inspector or medical officer, are in such a condition as to be a nuisance or annoyance to any inhabitant of the district, must be cleansed by the defaulter, under penalty, or by the persons having use in common, if the defaulter is unknown (Sec. 21).

Separate sanitary conveniences must be provided for both sexes where employed in any building used as a workshop or manufactory, etc. (Sec. 22).

This section, where in force, repeals Section 38 of the Public Health Act, 1875, or 48 of the 1878, Irish Act, which refer to the provision of such accommodation, if the local authority *think fit*.

Section 23 extends the provisions of Section 157 of the Public Health Act, 1875 (41 of the 1878 Irish Act), to, among other items, the keeping waterclosets supplied with sufficient water for flushing; and any by-laws made under that section, as above extended, may be made so as to affect buildings erected *before* the times mentioned in the said section.

These provisions shall be in force in every rural district where this part of this Act is adopted.

No rooms which are over any privy (not being a water-closet or earth-closet), or immediately over any cesspool, midden, or ashpit, shall be occupied as a dwelling or sleeping-place, or work-room, or place of habitual employment, after not less than seven days' notice from the authority (Sec. 24).

By-laws may be made by an urban authority for:—Prescribing the times for the removal or carriage of any fæcal, or offensive, or noxious matter or liquid through the streets of their district; and for providing for the proper construction and covering of the receptacle, or cart, etc., used.

Any person aggrieved by the order, requirement, etc., or by the local authority withholding any such order or certificate under this Act, or by any conviction or order of a court of summary jurisdiction thereunder, may appeal to quarter sessions.

With regard to investing rural authorities in Ireland with urban powers, the Local Government Board for Ireland may do this, either on the application of the sanitary authority of any rural district, or of persons rated to the relief of the poor, the assessment of whose hereditaments amounts at the least to one-tenth of the net rateable value of such district, or of any contributory place therein. As regards the latter, an Order of the Board made on the application of such ratepayers shall not invest the rural authority with any new powers beyond the limits of such contributory place (Public Health (Ireland) Act, 1896, Sec. 1).

The provisions of Sections 16, 17, 18, 19, and 21 are applicable in rural areas (Sec. 50). The Local Government Board may also declare that any provisions of this Act shall extend to rural districts (Sec. 5).

APPENDIX D.

Public Health Acts Amendment Act, 1907 (England and Wales and Ireland).

This Act, like the 1890 one, applies to England and Wales and Ireland (exclusive of the administrative county of London). Like it, it is adoptive by Order of the Local Government Board in London or Dublin (as the case may be) on the application of a local authority. Any part or any section of the Act may be put in force in that manner, excepting the three parts which refer to police, fire brigade, and sky signs (Sec. 3).

Part III., Sanitary Provisions, is the only part which concerns our subject, and where adopted the following provisions come into operation:—

Any gutter or drain which causes damp in any building by reason of its insufficiency or its defective condition shall be deemed a nuisance under the Public Health Act, 1875, or 1878 (Ireland), as the case may be (Sec. 35).

Rain-water pipes are not to be used as soil pipes; nor are water or stack pipes to be used as a drain ventilating shafts, under penalties not exceeding £5 and a daily one of £2 in the former case; and in the latter (after fourteen days' notice from the authority) of £2 and £1 respectively (Secs. 36 and 37).

The local authority may, on the report of the Surveyor, Medical-officer, or Inspector, duly authorised in writing by the authority (Sec. 41) give written notice to the owner of a building not provided with sufficient closet accommodation, and if such cannot be provided by the alteration of any existing closet accommodation, provided there are a sufficient water supply and sewer, to require the provision of sufficient water or slop closets.

If there are a sufficient water supply and sewer, the notice may require the conversion of existing closet accommodation (other than a water or slop closet) into either of such closets. In default of the work being carried out within the time specified in the notice, but not less than fourteen days after its service, the local authority may execute the same and recover the expenses incurred from the owner summarily

(Sec. 39). As regards a slop closet, the authority must satisfy the Local Government Board that the circumstances of the district call for the provisions of this section with respect to a slop closet.

Where the work has been carried out for the common benefit of two or more buildings belonging to different owners the expenses shall be payable by the owners in such proportions as shall be fixed by the authority's surveyor, or in case of dispute by a court of petty session (Sec. 41). Where any work of alteration is done by the authority in default of the owner in respect of a pail closet (including a moveable receptacle) (Sec. 39) such expense shall be borne by the authority. Similarly, in the case of any existing closet accommodation other than a pail closet, the expenses shall be borne as to half by them and the other half by the owner or owners, and shall be recoverable in a summary manner. The effect of this sub-section must be stated in every notice thereunder.

Any expenses incurred by a local authority, and recoverable summarily by them, may be declared private improvement expenses under Sec. 257 of the Public Health Act, 1875, and Sec. 229 of the Ireland Act, 1878 (Sec. 40).

The authority may, on the report of the Surveyor, Medical-officer, or Inspector that any building is unprovided with a proper sink or drain or other necessary appliances for carrying off refuse water, require such provision. The notice shall specify the manner and time (not less than twenty-eight days), in which the work is to be carried out, and in default the authority may execute the work and recover the expenses summarily as a civil debt from the owner or occupier, who shall also be liable to a penalty not exceeding £5, and a daily penalty not exceeding £2 (Sec. 49).

Drains considered by the Medical-officer, Surveyor, or Inspector on reasonable grounds to be defective and consequently dangerous or injurious to health may be tested by either of such officers duly authorised by the authority, and with the consent of the owner or occupier, or an order of a court of summary jurisdiction. He may test the drains by smoke or coloured water, or other similar test (not including a test by water under pressure). All reasonable facilities shall be given by the owner or occupier, in default of which he shall be liable to a penalty not exceeding £2, and to a daily penalty not exceeding £1 (Sec. 45). The authority may require existing drains to be laid open for examination by the surveyor before their connection with any of their sewers (Sec. 38).

In the event of the drains being found defective, the local authority may give the owner written notice requiring the execution of all necessary works within a reasonable time named therein. In default the work may be executed by the authority, and the expenses incurred are recoverable summarily, or as private improvement expenses (Sec. 45).

Where a cesspool or other receptacle used or formerly used for excreta or other obnoxious matter, or for the whole or any part of the drainage of a house, is in such a condition as to be prejudicial to health, or otherwise objectionable for sanitary reasons, in the opinion of the Medical-officer, Surveyor, or Inspector, and is so reported to the authority, the latter may serve a written notice requiring the owner or occupier of the house or part of a house in question, within a reasonable time specified therein, to cause such cesspool or receptacle to be filled up or removed, and any drain in connection to be effectually disconnected, destroyed, or taken away. If such cesspool or receptacle is used in common by the occupiers of two or more houses, or parts of houses, the notice shall be deemed to be properly served if delivered to any one or more of the owners or occupiers of such houses. In default the local authority may carry out the work, and recover the cost from the owners or occupiers summarily, or as private improvement expenses.

By Sec. 34 an important extension is made to Sec. 41 of the Public Health Act, 1875 (Sec. 51 of the Irish Act of 1878), which provided for the examination of any drain, water or earth closet, privy, ashpit, or cesspool, on the written complaint of any person to the authority that it was a nuisance or injurious to health ("but not otherwise"). This section, where in force, enacts that the provisions of Sec. 41 (or 51) shall have effect as if for the words ("but not otherwise") there were substituted the words "or where on the report in writing of their Surveyor or Inspector of Nuisances the local authority have reason to suspect that any such drain, water closet, earth closet, privy, ashpit, or cesspool is a nuisance or injurious to health."

Thereafter, the sections in question would provide for any sanitary officer, having the written authority of the Council, and after twenty-four hours' written notice to the occupier of such premises, or in case of emergency without notice to enter thereon and examine such drain, etc., the ground being opened, if necessary. If the drain, or closet, etc., is found to be in proper condition, he shall cause the ground to be closed as soon as can be, and the expenses of the works shall be defrayed by the person making the abovementioned written application. Otherwise the authority shall forthwith cause written notice to be given to the owner or occupier of the premises requiring him forthwith, or within a reasonable time therein specified to do the necessary works. In default the authority may, if they think fit, execute such works, and recover the costs from the owner summarily, or as private improvement expenses, and the person on whom the notice is served shall be liable to a maximum penalty of ten shillings for every day during which he makes default.

APPENDIX E.

The Burgh Police (Scotland) Acts, 1892 and 1903.

The 1892 Act applies to every existing burgh in Scotland, with the exception of Edinburgh, Glasgow, Aberdeen, Dundee, and Greenock, which have special Acts of their own, and to every burgh created under the Act, from the date when its creation is recorded in the Sheriff Court Books. Unless otherwise provided it repeals and supersedes all general or local Police Acts.

The Act of 1903 is in part optional. Part I., however, is applicable to all burghs, as set out above which are under the 1892 Act.

Part I. (General) comprises Register and other provisions as to streets, buildings, *sewers*, etc., as well as rating and borrowing powers, and miscellaneous provisions, including power to town commissioners, town councils of burghs, by the Town Councils (Scotland) Act, 1900, to oppose Bills and Provisional Orders.

In most burghs, as will be noticed, the law as regards the sewer assessments, and becoming security for the payment of interest, and the repayment of money borrowed for the execution of sewerage and drainage works, has been amended by the Burgh Sewerage, Drainage, and Water Supply (Scotland) Act, 1901.

The Burgh Police Act, 1892.

Some Definitions.

The following definitions, contained in Part I. (Sec. 4 of this Act), as amended by Section 103 of the 1903 Act, will be useful in connection with these notes.

"**Building**" shall include any structure or erection of what kind or nature soever, whether temporary or permanent, and every part thereof excluding hoardings.

The words whether "temporary or permanent," and as to the hoardings were added by the 1903 Act.)

"**House,**" unless otherwise expressed, means dwelling-houses, out-houses and other erections, being pertinents of the house.

"**Public building**," a building used, or to be used, as a church, chapel, or other place of public worship, or as a school, college, or place of instruction (other than a dwelling-house so used), hospital, poor-house, public theatre or music hall, hall, concert-room, ball-room, library, place of assembly, or a building used or intended to be used for any other public purpose, including, similarly, an hotel, lodging-house, home, refuge, or shelter, which contains more than 250.000 cubic feet, or has sleeping accommodation for more than one hundred persons.

"**Lands and Premises**," include all lands, springs, rights of servitude, dwelling-houses, shops, warehouses, vaults, cellars, stables, breweries, manufactories, mills, and the fixed or attached machinery therein, yards, places, and other heritages, specified or included in the Acts for the valuation of lands and heritages in Scotland in force for the time being.

"**Occupier**" means tenant or sub-tenant, or any person in actual occupancy; but not including a lodger or tenant of a furnished house let for less than one year; but includes the person by whom such furnished house is so let.

"**Owner**," includes joint owner, fiar, liferenter, feuar, or other person in the actual possession of, or entitled to receive the rents of lands and premises of every tenure or description, and the factor, agent or commissioner of such persons or any of them, or any other person, who shall intromit with or draw the rents.

(Under this definition a factor's liability was very wide, and to limit this a section (58) was included in the 1903 Act, by which any factor, agent, or commissioner, "shall be liable to the extent only of the funds, rents, and other assets belonging or payable to such owner which may be in, or may come into, his hands or control.")

"**Burgh**" when used alone, unless otherwise expressed, or inconsistent with the context, shall include royal burgh, Parliamentary burgh, burgh of regality, burgh of barony, and any 'populous place' or 'police burgh' administered in whole or in part under any general or local Police Act, or any burgh created under this Act."*

* See also the Burgh Sewerage, Drainage, and Water Supply Act (1901), p. 289.

"**Police burgh**" "shall mean a 'populous place,' the boundaries whereof have been fixed under the general Police Acts, or under any local Police Act, or this Act."

"**Populous place**" "shall mean any town, village, place, or locality, containing a population of 700 inhabitants or upwards, not being administered under any general or local Police Act; and for the purposes of this Act two or more contiguous towns, villages, places, or localities not being burghs, may be held to be a 'populous place.'"

"**Street,**" "shall include any road, highway, bridge, quay, lane, square, court, alley, close, wyand, vennel, thoroughfare, and public passage or other place within the burgh, used either by carts or foot passengers, and not being or forming part of any harbour, railway, or canal, station, depôt, wharf, towing-path, or bank."

The 1903 Act, by Section 103, extends this definition, and also defines the expressions "private" and "public" "street," "part of a street," and "lane," as hereunder set out:—

"**Public street**" means any street taken over, or to be hereinafter taken over as a public street under any Police Act by the local authority; any highway within the meaning of the Roads and Bridges (Scotland) Act, 1878, vested in the town council; any road or street which has otherwise become, or shall hereafter become, vested in the council; and any street entered as a public street in the register of streets made up under the 1903 Act.

"**Private street,**" is, for the purpose of the 1892 and this Act taken to mean any street, other than a public street not maintained by the town council.

"**Part of a street**" is defined as "any area within a street, whether including the whole length or width of the street or not."

"**Lane,**" means "any street of fifteen feet or under in width which is used wholly or mainly for access to stables or other buildings, not abutting upon a street of greater width, or as a back access to dwelling-houses or other buildings facing a street of greater width."

"**Commissioners**" of towns are mentioned throughout the 1892 Act, but under that of 1903 are referred to as the "town council." This change is due to the Town Council's (Scotland) Act, 1900.

"**Court,**" where, by the context, it applies to a space contiguous to buildings, shall mean a court, recess, or area forming a common access to lands, and premises separately occupied, including any common passage or entrance thereto.

Public Sewers.

It should be remarked here that no definition is given in this Act of the expression "sewer"; nor is "drain" defined. In the Burgh Police (Scotland) Act, 1903 (Sec. 103), drain is defined as including "All soil pipes, and all other pipes, traps, and apparatus used for, or in connection with, the removal of sewage or waste water."*

By Section 215 all existing and future sewers within a burgh (save private branch drains made and used for the purpose of draining, preserving, or improving land, and sewers made under any local or private Act) are vested in and under the management of the Commissioners (by the Burgh Police Act, 1903, styled the Town Council) who, by Section 216, may purchase the rights and privileges of any person for making sewers, or contract for the use of or purchase any sewers with or without buildings, works, materials, etc., belonging thereto. The perpetual rights of any person to the use of such sewers are to remain therein, or shall remain in a substituted sewer.

By Section 217, no private sewer or water course, or any work for draining, preserving, or improving land, or for or in respect of any mills, mines, machinery, canal, or navigation under any private or local Act, is to be interfered with, without the written consent of the person legally entitled to grant the same.

Formation of Burgh Drainage Areas.

Section 218, dealing with the formation of Burgh drainage districts subject to the approval of the Sheriff, is as follows:—

The Commissioners (town council) shall form the whole burgh into one drainage district, subject to the following exceptions and provisions:—

(1) Where, at the application of this Act, separate districts exist, they shall be so maintained, unless and until they are altered in the manner hereinafter provided.

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* See Sections 101-123 of the Public Health (Scotland) Act, 1897 and reference under Sections 241-245 of the Burgh Police (Scotland Act, 1892.

(2) The Council may divide the burgh into separate drainage districts, if special and exceptional circumstances exist to the Sheriff's satisfaction; or may unite or alter existing separate districts.

(3) Any alteration of districts existing at the application of this Act, shall be subject to such conditions as they may impose, having regard to the assessments which have been paid in the existing districts.

(4) The Burgh Surveyor shall prepare a plan of the several drainage districts, and from time to time make any necessary alterations thereon. (See also Sections 210—214.)

(As to Burghs and special or separate drainage districts, to which the Burgh Sewerage, Drainage, etc., Act, Sections 2 and 3, apply, see page 289.)

Burgh authorities may either carry out drainage works under this Act or under the provisions of Section 103 of the Public Health (Scotland) Act, 1897.

Section 220. Not less than twenty-eight days' notice must be given by posting a notice in a conspicuous place at each end of every street where any new sewer is to be laid where none previously existed, or where it is proposed to alter the course or level of or abandon or stop any sewer. The Council's notice shall state the names of the streets and places through or near which the work is to be executed, and shall specify a place where plans may be seen, and also time and place where all persons interested in the intended work may be heard thereupon.

Section 221. The Council shall meet at the time and place mentioned in the notice with their Surveyor to hear any objections by interested persons, or those likely to be aggrieved by the proposed work. The Council have full discretion to abandon or make any alterations as they deem fit; and no such work to which any objection is made at such meeting shall be executed unless the Burgh Surveyor, after the person making such objection or his agent has been heard, shall certify that the work ought to be executed, nor shall such work be begun until the end of seven days after an order for the execution thereof has been duly made by the Council, and entered in their books.

Section 222. Whenever the Council shall have caused pipes or other works for sewage to be laid in or along any stream in order to intercept and convey away the sewage which would otherwise flow into and pollute the same, no person must pollute the water* by allowing sewage or offensive matter to flow therein. If any lands and premises would in the ordinary way drain into such river, burn, etc., the Council must allow junctions to be made with their sewers, on such terms as may be arranged, or fixed by the Sheriff, under a penalty in default.

Construction of Sewers and Sewerage Works.

In addition to powers under this Act, most authorities have, under the Burgh Sewerage, etc., Act, 1901, Sec. 5, the powers and privileges under the Public Health (Scotland) Act, 1897, which refer to sewerage and drainage thereunder, save under Secs. 121 and 131, which refer to districts other than burghs.

With regard to the construction of new sewers, where none exist, Section 219 provides that the Commissioners (Town Council), subject to the restrictions therein contained as to the notice to be given (under Sec. 336) and the plans and estimates to be prepared (Secs. 214 and 226), shall cause to be made, under the streets or elsewhere, such main and other sewers as shall be necessary for the effectual draining of the burgh, and shall also cause to be made all such reservoirs, sluices, engines, and other works as shall be necessary for cleansing such sewers, and if needful they may carry such sewers through and across all underground cellars and vaults under any such streets, doing as little damage as may be, and making full compensation for any damage done; and may carry the same into or through any enclosed or other lands, making full compensation to the owners and occupiers thereof. And they may cause the refuse from such sewers to be conveyed by a proper channel to the most convenient site for its collection and sale for agricultural or other purposes, as may be deemed most expedient, but so that the same shall in no case become a nuisance. Provided always that if in making any such main and other sewers, or in repairing, constructing, or enlarging the same or existing drains or sewers, the contents at present carried into any existing outlet shall be diverted therefrom to the prejudice of any actual existing legal right, the Commissioners (Town Council) shall be bound to make compensation thereon. Compensation under this section shall be settled in the same manner as compensation for land to be

* See also Rivers Pollution Prevention Act, 1876, Section 3, p. 292.

taken under the provisions of the Lands Clauses (Scotland) Acts is directed to be settled.*

Estimates and Plans of Sewerage Works.

Section 213 empowers the Town Council to cause their Surveyor to prepare plans of any new works for the effectual drainage of lands or premises within the burgh, or alterations to existing works. The plans should show the lines that appear to him most suitable for the main sewers, and the best position for outfalls and sites for the collection and sale of filth and refuse for agricultural or other purposes.

By Section 226, the Town Council must procure from their Surveyor, before entering into any contract for the work, an estimate of the probable cost of executing the works and the yearly cost of keeping in repair, as set out in Sec. 225, and the estimate shall be accompanied by a report as to the best mode of arranging for the construction and maintenance of such work, whether under a contract for construction only, or for construction and maintenance in repair during a given term of years.

Town Councils may borrow money for the execution of sewerage works, under the provisions of Secs. 236, 374, of this Act, as amended by the 1893 Act and the Burgh Sewerage, etc., Act, 1901 (see p. 289).

Sundry Provisions as to Water Protection, Sewers, and Drains.

Section 223. No person shall throw or cause or procure to be laid or thrown, any rubbish, earth, ashes, or refuse, whether offensive or not into any stream flowing through or on the boundary of the burgh, under a penalty not exceeding 40s. The Rivers Pollution Prevention Act, 1876, has a section (2) to prevent interference with the free flow of, or the pollution of, the waters of streams (see p.).

Section 224. The Council may alter, repair, extend, or improve from time to time any sewers vested in them, or demolish same, provided no nuisance is caused. But, by Section 225, existing sewers or drains must not be destroyed without the provision of others; if so, an aggrieved person may recover, after written notice served on the Council, a penalty of forty shillings for every day during the deprivation. By Section 25 of the 1903 Act, the Council may make

* See p. 306 *et seq.*

the necessary connections of the branch drains with the new sewer, and, except so far as the length of any new branch drain may exceed that of the former drain, may recover the cost from the owner of the house or building served thereby as private improvement expenses.

The penalty for making an unauthorised drain from any lands or premises into any of the sewers vested in the Council is, by Sec. 227 as amended by the Burgh Sewerage Act, 1901 (Schedule), one not exceeding £5. No building shall be erected over any of the Council's sewers without their written consent (Sec. 228).

By Section 229 all sewers and drains, whether public or private, are to be trapped and ventilated by whomsoever they are owned; and, by Section 230, the Council may acquire lands and premises by agreement only, and construct all ventilating shafts, furnaces, and other means of ventilating and other works which may from time to time be found necessary. If it is found necessary to carry them upon, into, or through any enclosed or other private premises, the Council may proceed under the powers and liabilities provided by this Act with reference to the construction of sewers (see Sec. 219). By Sec. 231, the Council may arrange for ventilation with the owners or occupiers of any manufactory, gas works, or brewery, having furnace and chimney shafts so situated as to be available for the ventilation of the adjacent sewers and drains, or with the owners of other suitable premises, and to lay and fix such ventilators, pipes, or shafts into, on, or against all such buildings or premises as to them may seem proper, and as may be agreed on, making compensation to the owners.

By Section 233, distillers, manufacturers, and owners or occupiers of other works, must not cause or permit any refuse, refuse water, steam, or other substance likely to interrupt the free passage of a sewer, or likely to be otherwise injurious thereto, or likely to be injurious to the health of persons living in the vicinity, to enter a public sewer, river, inland loch, public reservoir or dock, under a penalty. Such owners and occupiers shall construct pools or reservoirs as near their works as possible, for receiving such refuse, etc.

Section 234. The owner or occupier of any lands or premises beyond the burgh, or not included in one of its drainage districts, may, with the written consent of the Council, upon payment of a reasonable agreed sum and under the superintendence of the Council's Surveyor, drain such premises or land into the Council's sewers.

By Section 235. If the Council consider it necessary for public health, they shall be entitled, with the consent of the Board of Trade, to cause any drain to discharge below high-water mark.

Appeal may be made to the Sheriff by any person whose property may be taken or injuriously affected by the making, altering, and maintaining sewers (Secs. 245 and 339).

If any party is dissatisfied with the Sheriff's judgment, and deems it erroneous in point of law, he may appeal against the same to the Court of Sessions (Sec. 104, 2 (S.) of the 1903 Act).

Under Section 210, the Town Council must provide a survey and map or maps of the burgh on a scale of not less than twenty-five inches to a mile, upon which should be marked the course of all existing sewers and drains belonging to them or under their care or management, and also showing any additions thereto. They shall be kept in the Burgh Clerk's office, open to inspection at all reasonable hours.

Upon the maps shall be marked the level lines and bench marks.

Burgh Police (Scotland) Acts, 1892 and 1903. Drainage of Houses.

Section 238 gives power to the Council to construct drains from houses, in their opinion, insufficiently drained into some sewer or the sea, charging the owner, etc., with the expense. By the 1903 Act, Sec. 104, Sub-sec. 2 (n), the following provisions operate :—

If there are such means of drainage within 100 yards of any part of such house or building, the Council may require the owner to construct therefrom a covered branch drain or pipe of such material, size, level, and with such fall as they may deem necessary for the drainage of such house or building, its areas, water closets, and offices. In default of such means, the Council may require the owner to construct from such house, etc., a drain as above, leading into a covered cesspool or other place to be constructed by the owner, subject to the conditions as to construction and repair set out in Sec. 239, which provides for the Council's approval of the work, and that no house or building may be built upon a lower level than will allow the drainage to fall into a council's sewer. The provisions of this section are amended by Sec. 104 of the 1903 Act, under which, if the work is carried out by the Council, the expenses are recoverable from the owner as private improvement expenses.

Sections 241-245. House drainage is to be properly ventilated and trapped, if required by the Council, under whose survey and control it shall be. Drains and cesspools are to be kept in proper order by owners at their own expense.

The Surveyor, Sanitary Inspector, or Medical-officer of Health may inspect any drain, cesspool, or reservoir during the day time (usually considered from 9 a.m. to 6 p.m.), after twenty-four hours' written notice to occupier of the premises to which such drain, etc., is attached, and may enter thereon with necessary workmen to open up the ground, to examine drain, etc. If found in proper order and condition, the ground to be closed and made good at the Council's expense; and all branch drains open for repairs or for any other purpose shall not be covered up before inspection by the Council or their Surveyor, under a penalty of £5.

As regards "drains," Sec. 103 (7) of the 1903 Act. for the purpose of Sec. 241-245 of that of 1892, extends the powers of Town Councils as to branch drains to soil pipes, and all other pipes, traps, and apparatus used for or in connection with the removal of sewage or waste water, which form part of house drainage systems.

Compulsory Powers of Purchase of Lands.

By Secs. 60 of the 1892 Act, and 57 of the 1903 Act, the Town Council may acquire land compulsorily under the Lands Clauses (Scotland) Acts with the authority of the Sheriff. The former section provides for their presenting a petition to the Sheriff for authority to put in force the powers of the said Acts with respect to the purchase and taking of lands or premises otherwise than by agreement. A plan should accompany the petition showing the lands or premises to be taken, and also a book of reference relative to the said plan, giving the names of the owners or reputed owners, lessees or reputed lessees, and occupiers of the lands, etc., proposed to be taken. The Sheriff shall thereupon direct fourteen days intimation to be given to the above-named persons of the time, place, and subject of the inquiry to be held in reference to the property. He shall then make such inquiry as he may consider necessary into the subject matter of the petition and plan, and he may call for any information from the Council and others, and grant a deliverance in accordance with the petition, or with such modifications or alterations as may seem to him requisite, or he may refuse to grant the petition.

The Town Council, or any owner or occupier whose property may be affected by the Sheriff's decision, may appeal to the Secretary for Scotland, who may order further inquiry, or take any other steps as may seem to him desirable, and thereafter issue an order relative to the matters of the petition, as he deems requisite, and also as regards the costs, etc., in relation to the order.

By Sec. 57 of the 1903 Act, in cases of disputed compensation for land taken compulsorily by a Town Council, the Secretary for Scotland, unless both parties concur in the appointment of a single arbiter, may, on the application of either party, appoint one who shall occupy the same position as a single arbiter under the Lands Clauses Consolidation Acts. Where special provisions are made in any public general Act for the appointment of a single arbiter for determining compensation for the acquisition of land, this section shall not apply.

Construction of Sewerage Works.

Under Sec. 108, the Town Council may provide lands *within* or *without* the burgh for the *deposit, treatment, and disposal of the night soil, etc.*, and may purchase or hire lands or premises therefor, either by agreement or otherwise, under the Lands Clauses Acts. They may also erect buildings, machinery, and plant upon any land so purchased or hired.

Borrowing Powers under the Burgh Police (Scotland) Acts, 1892 and 1903, and the Burgh Sewerage Act, 1901.

Sections 236 and 374 of the 1892 Act, as amended by Secs. 47-49 and 104 (3) v. of the 1903 Act, and Secs. 1, 2, 4 (1), and 5 of the Burgh Sewerage Drainage and Water Supply (Scotland) Act, 1901, which together may be cited as the Burgh Police (Scotland) Acts, 1892 to 1903, regulate the borrowing powers of burgh authorities under the Acts, for the general purposes thereof.

Under Sec. 236 the Town Council may borrow money for purchasing, making, enlarging, ventilating, reconstructing, and maintaining sewers on the security of the special and general sewer rates.

The other sections referred to deal with the procedure in giving public notice by newspaper advertisements, etc., relative to the money proposed to be borrowed by the Town Council.

By Sec. 379 the Town Council may borrow money from the Public Works Loan Commissioners on the security of the rates, repayable within a period not exceeding thirty years by such instalments and at such times as may be agreed upon. By Sec. 142 of the Public Health (Scotland) Act, 1897, the sanitary works, in respect of which the loan is required may either be already executed or about to be so. By Sec. 374, as amended by Sec. 104, Sub-sec. (2) (v.) of the 1903 Act, no sum of money shall be borrowed by the Town Council until an estimate has been laid before them, or until the expiration of three weeks after the Council have given public notice, as provided above, of their intention to borrow.

In connection with our subject, the Burgh Sewerage, Drainage, and Water Supply (Scotland) Act, 1901, Part I., relates to the amendment of the law as regards the sewer assessments in any burgh, or in any special or separate drainage district therein, and the security for the payment of interest and the repayment of capital borrowed for sewerage and drainage works.*

Service of Notices.

By Section 336 notices may be in print or in writing, or partly print and partly in writing, and may be authenticated by the name of the clerk or other proper officer being similarly affixed thereto. If addressed "to the owner" "or occupier" of the premises (naming them) to which a notice relates, it may be served either personally or through the Post Office, addressed to him at his usual or last known place of abode or business, or by delivery to some inmate thereof, or in case of an occupier it may be delivered to an inmate of the building to which the document relates; or if unoccupied, and the place of abode of the person in question cannot after due inquiry be found, it may be served by affixing the notice, or a copy, upon some conspicuous part of such building. If the person is employed on any ship or vessel, it may be served by leaving it in the hands of some person on board and connected therewith.

If any owner resides outside the jurisdiction of the burgh magistrates, he may be cited by delivering the citation to his factor, or agent, or any person drawing the rents (if known); or, in default, the occupier of the premises, or any of them may be cited and shall take burden for the owner or owners, and have right of relief against such.

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* See Sections 1 and 2 of the Act, p. 289.

As to service of notices on the Town Council under Sec. 338, they may be delivered to the Clerk of the burgh, or sent by registered letter directed to him, in which latter case service shall be deemed to be effected on the day on which such letter would be delivered in the ordinary course of post.

By Section 337 the person sending such notice may cancel or vary it ; save that, if the notice is under the Land Clauses Acts, it may not be withdrawn or cancelled, except so far as allowed by such acts.

Private Improvement Expenses and Special Rates.

Under Sec. 365 provision is made for cases where the local authority carry out any work on behalf of an owner or occupier through his or their default, or where expenses are incurred by the Town Council in respect of any premises in order to carry out the provisions of the Act, empowering them to charge such persons with the expenses incurred by them. They shall be called "private improvement expenses," and are recoverable in the same manner as any assessment under this Act. In the event of different portions of the premises in question belonging to two or more separate owners, the said expenses are recoverable from them in proportion to the rental or valuation of their respective interests as set out in the valuation roll. The Council may charge as part of such expenses a reasonable sum in respect of superintending the work, etc. (Burgh Police Act, 1903, Schedule, and Sec. 104 (2) (u)).

With regard to sewer assessments, the Burgh Sewerage, Drainage, and Water Supply (Scotland) Act, 1901, repeals nearly all the provisions relative to this matter in burghs to which it applies, i.e., burghs to which the Burgh Police (Scotland) Act, 1892, *applies*, but not where a local Act was in force at the passing of the 1901 Act (including an Act confirming a Provisional Order) with respect to sewerage and drainage. In either of such cases, however, the Town Council may pass a resolution to adopt Part I. of the 1901 Act, which deals with the amendment of the law relating to the sewer assessment, becoming security both for the payment of interest and the repayment of the money borrowed for purposes of sewerage and drainage.*

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* See p. 289.

Appeal.

By Sec. 339 of the 1892 Act, as amended by that of 1903, Sec. 104 (2) (5), any person liable to pay or contribute towards the expense of any work ordered by the Town Council under the 1892 Act, and any person who thinks himself aggrieved or affected by any order, or resolution, or act of the Town Council under such Act, may appeal either to the Sheriff or to the Court of Sessions, as provided by these sections.

Provisional Orders.

If the Town Council consider they require additional powers as to drainage or sewers, or the *utilisation of sewage*, in addition to the powers conferred by the Public Health Acts, or for the repeal or amendment of any local Acts relating thereto, etc., they may apply to the Secretary for Scotland for a Provisional Order under Secs. 45-49 of the 1892 Act.

APPENDIX F.

The Public Health (Scotland) Act, 1897.

Some Definitions.

For the purpose of these notes, the following definitions, set out in Sec. 3 of this Act, may be found useful :—

"**Burgh**" includes not only royal or parliamentary burgh, and burgh incorporated by Act of Parliament, but also any police burgh within the meaning of the Burgh Police Act, 1892, Sec. 4 (25).*

"**Parish**" means a parish quoad civilia, exclusive of any burgh partly or wholly situated therein, and is taken to mean landward part of the parish.

"**County**" means a county exclusive of any burgh, but does not include a county of a city. The Interpretation Act, 1889, Sec. 7, has a definition which includes stewartry.

"**District**" means the district of any local authority under this Act, and infers both burghal and landward areas. By Sec. 12, the authority for administering the Act is the Burgh Commissioners, or Town Council (under the Town Council (Scotland) Act, 1900) in burghs to which the Burgh Police Acts, 1892 and 1903, apply. In Edinburgh, Glasgow, Aberdeen, Dundee, and Greenock, to which those Acts do not apply, the authority is the Town Council.

"**District Committee**" refers to the committee of each of the districts, into which all Scotch counties (except eight) are divided for public health purposes under the Local Government (Scotland) Act, 1889, as amended by the 1894 Act. It includes the County Councils of Caithness, Clackmannan, Elgin, Kinross, Nairn, Peebles, Selkirk, and Sutherland, which, as mentioned above, are not divided into public health districts. As regards the *acquisition of lands*, district committees are *not* empowered to purchase, therefore in landward areas such powers must be exercised by the County Council.

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* See p. 259.

"**Premises**" includes lands, buildings, vehicles, tents, vans, structures of any kind, streams, lakes, seashore, *drains*, ditches, or places open, covered or inclosed, whether built on or not, public or private, natural or artificial, and whether maintained under statutory authority or not.

"**Land**," both in this Act and in the Acts incorporated therein, includes water, and any right or servitude to or over land or water. (Where the Lands Clauses Consolidation Acts are incorporated in this Act, it should be noted that under Sec. 4 the definition of "land" does not expressly include water.)

By Sec. 3 of the Interpretation Act, 1889, "land," unless otherwise stated, includes messuages, tenements, and hereditaments, houses, and buildings of any tenure.

"**Street**" includes any highway, and any public bridge, and any road, lane, footway, square, court, or passage, whether a thoroughfare or not, and whether or not there are houses in such street.

"**House**" means a dwelling-house, and includes schools, also factories and other buildings in which persons are employed.

"**Factory**" includes workshop and workplace. By the Factory and Workshop Act, 1909 (which applies to the United Kingdom), these expressions are given very wide meanings. "Factory" refers to textile and non-textile factory. The former deals with any premises wherein mechanical power is used in connection with cotton, wool, flax, hemp, jute, silk, etc., print-works, lucifer-match works, iron or copper mills, foundries, paper mills, tobacco factories, printing or bookbinding works, electrical works, in which electricity is generated or transformed for supply by way of trade, or for the lighting of any street, public place, or building, or of any hotel, railway, mine, etc. "Non-textile factory" refers to hat works, rope works, bake-houses, lace making, dry cleaning, carpet beating, and bottle washing works; also shipbuilding yards, quarries, pitbanks, etc.

The expression "tenement factory" is also used.

"**Workshop**" means any premises or places as mentioned above under non-textile factory; also any premises, room, or place whereon any manual labour is exercised for purposes of gain; for making, altering, repairing, ornamenting, or finishing any article or part thereof, or the adapting for sale of any article.

A "**tenement workshop**" is included under the expression "workshop," and means any work place where two or more persons carry on any work, referred to in connection with a workshop, with the owner's or occupier's sanction.

(See further the Factory and Workshop Act, 1901, Section 149 and Parts I. and II. of Schedule VI., and Section 159.)

"**Owner**" means the person for the time being entitled to receive, or who would if the same were let, be entitled to receive, the rents of the premises, and includes a trustee, factor, tutor, or curator, and in case of public or municipal property applies to the persons to whom the management thereof is entrusted.

"**Occupier**" means, in the case of a building or part thereof, the person in occupation or having the charge, management, or control thereof, either on his own account or as the agent of another person. "Company" includes Commissioners.

"**Author of a Nuisance**" means the person (by Section 19 of the Interpretation Act, 1889 this includes any body of persons, corporate or unincorporate) through whose act or default the nuisance is caused, exists, or is continued, whether he be the owner or occupier, or both.

"**Nuisance,**" by Section 16, means any premises or part thereof of such a construction or in such a state as to be a nuisance or injurious or dangerous to health; and includes any water or earth closet, privy, urinal, cesspool, or *drain* in a foul condition. The Burgh Sewerage, Drainage, and Water Supply (Scotland) Act, 1901, Section 5, enacts that the provisions of this Act, with reference to sewerage and drainage (and water supply), shall extend *to the whole area of the burgh* as existing for the purposes of the 1897 Act, and that the town council of any burgh, under the Burgh Police (Scotland) Act, 1892, shall, by the 1901 Act, have conferred upon them, in addition to their powers under the 1892 Act, the same rights, powers, and privileges conferred by the 1897 Act upon local authorities in districts *other than burghs*.

By Section 8 of the Burgh Sewerage, etc., Act, 1901, the Act shall *not* apply to (1) any burgh outside the scope of the Burgh Police (Scotland) Act, 1892, (2) any burgh to which the provisions of the 1901 Act or a local Act (including an Act confirming a Provisional Order) is in force with respect to sewerage and drainage (or water supply). The town council of either of such burghs may by resolution adopt such provisons, and notify such resolution to the Secretary for Scotland.

Drains and Sewers.

This Act contains no definitions of the expressions "drain" and "sewer." Both are defined in precisely the same language for the purposes of the Public Health Acts in the Public Health (England and Wales) Act, 1875, Section 4, and the Public Health (Ireland) Act, 1878, Section 2.* It is considered, however, that in a general way the same definitions are applicable to the administrations of both the Public Health (Scotland) Act, 1897, and the Burgh Police (Scotland) Acts of 1892 and 1903. In Section 119 of the 1897 Act, it seems evident that the word "drain" includes a sewer, because the section authorises a local authority, if they "shall consider it necessary for public health that any *drain* shall discharge itself below low water mark," to construct the requisite works, subject to the consent of the Board of Trade, and the Commissioners of Woods and Forests (without prejudice to any question as to the right of foreshore).

Sewers and Drains are dealt with by Sections 101—123 of this Act.

Under Section 101, "all sewers, manways, lamp-holes, ventilating shafts, cesspools, surface gratings, and their connections, sluices, and all appliances pertaining thereto," are vested in the local authority. Those which are private property or are under the management of persons appointed by the Crown, or under any Act of Parliament, are exempted, as are also the rights of anyone to the property or management of any sewer under any existing local or general Police Act.†

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* See p. 239.

† In burghs, to which the Burgh Sewerage, Drainage, and Water Supply (Scotland) Act, 1901, applies, Section 101 ceases to operate. But this Act is not in force in burghs to which the Burgh Police (Scotland) Act, 1892, does not apply (see p. 289); nor in those in which a local Act (including an Act confirming a Provisional Order) operates in respect to sewerage and drainage. The Town Council of a burgh may, however, in cases where the Act does not apply, pass a resolution adopting Part I. of the Burgh Sewerage, Drainage, &c., Act, 1901, and inform the Secretary for Scotland (Sections 7 and 8). Part I. of the Act relates principally to the amendment of the Public Health Acts, as regards sewer assessments (see p. 289.).

The free flow of sewage, surface or storm water must not be interfered with, or any sewer or drain vested in a local authority (see Section 101) injured, by anything which may be thrown into or permitted to enter any such sewer or any drain communicating with same under a penalty, provided for in Section 117, not exceeding £10 and a daily penalty not exceeding £1, under the provisions of Section 153.

(The Rivers Pollution Prevention Act, 1876, has a section (2) on similar lines, to prevent the interference with the flow, or the pollution of the waters of a "stream" as defined thereby.)*

Section 118 imposes a maximum penalty of £10 for throwing the whole or part of the carcase of any animal into a drain or running water.

As to Drainage of Houses.

Section 120 enacts that, "If a house (by Section 3 it also includes schools, factories, and other buildings in which persons are employed), distillery, manufactory, or other works within the district of a local authority," is insufficiently drained, the authority may, by notice, require the owner of such premises to make a sufficient drain into one of the local authority's sewers, provided it be not more than one hundred yards from the site of the said premises; otherwise by emptying into such covered cesspool (which must not be a nuisance) or other place, not being under any house, as the authority may direct, within such reasonable time as is stated in the notice. In default, at the expiration of such time, the local authority may do the work and recover the expenses from the owner summarily, under Sections 153-4.

In such cases where the local authority are of opinion that "greater expense would be incurred in causing the drains of two or more houses to empty into an existing sewer," the authority may construct a fresh sewer and require the owners of such houses to cause their drains to discharge therein. The authority may apportion such expenses among the respective owners, and recover same in a summary manner, or, in case of dispute, the matter shall be determined summarily by the sheriff.

Drains must, by Section 115, be sufficiently trapped and ventilated. No drain must be made into any sewer vested in the local authority (Section 112) without the authority's consent.

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* See p. 292.

Section 110 empowers any owner or occupier of premises within a local authority's district, and liable for the public health general or special sewer assessment, to drain the same into the sewers of the authority, subject to twenty days' prior notice to them, and to complying with the regulations of the authority in respect thereof. Provided that the sewage so discharged is not of a nature to cause damage to the sewer or, by its mixing with other sewage therein, to cause a nuisance.

(This latter proviso is somewhat similar to the terms of Section 7 of the Rivers Pollution Prevention Act, 1876, which deals with the duty of local authorities to give facilities for the drainage of liquid wastes from manufactories into their sewers.)

With a similar proviso to that above, premises outside the district may be drained into the sewer of a local authority, provided that such sewer and any works in connection are sufficient in capacity and otherwise suitable for the reception of the drainage from such premises; and subject also to the owner or occupier agreeing to terms with the authority. In case of dispute, the matter shall be determined by the sheriff.

By Section 112, unless the consent of the local body has been given, no drain may be connected with a public sewer, under a maximum penalty of five pounds, and the authority may close such communication, and recover damages to cover the cost of making good the sewer as well.

No building (including a house), or cellar, etc., is to be erected over any public sewer without the consent of the local authority. This is provided for in Section 114, and Section 115 renders it necessary for all public and private sewers and drains to be sufficiently trapped and ventilated by their owners to the satisfaction of the authority. The local authority are hereunder responsible for all sewers vested in them under Section 101.

Sewer in Place of Ditch.

In the event of there being any water-course, ditch, gutter, or drain along the side of any street, "or between or parallel to rows of dwelling-houses, and used, or partly used, for the conveyance of any water, sewage, or other liquid, or matter from any premises," which "cannot, in the opinion of any local authority, be rendered free from foulness or offensive smell without the laying down of a sewer or some other structure," such local authority are required by Section 28 to lay down such sewer or other structure within the limits of their district, or without their district if necessary, for the purpose of outfall or distribution of sewage (see also Sections 103 and 108), for which purpose they may enter any premises, and use such part thereof as may be necessary. For such use they shall pay such damages as may be assessed by the sheriff on a summary application, provided, however, that any person who has caused or contributed to the fouling of any such water-course, ditch, etc., shall not be entitled to damages, unless he satisfies the sheriff that he had a "justifiable excuse for so doing."

Acquisition of Lands.

Lands for sewerage works purposes may be acquired by both burghal and landward local authorities, under Section 103, either for the whole of their district, or any special drainage districts formed under the provisions of Section 122 of this Act. The commissioners of burghs—since the Town Councils (Scotland) Act, 1900, the town council—have similar powers under Section 219 of the Burgh Police Act, 1892, but these relate only to lands within their own jurisdiction; therefore, if it is necessary for purposes of outfall works, or disposal, or treatment of sewage, or otherwise, to go outside a burgh, Section 103 of the 1897 Act should be followed, unless a special Act or Provisional Order is obtained. If money has to be borrowed for the execution of works, Section 139 must be brought into operation.

"Lands," as defined by Section 3, includes water and any right or servitude to or over land or water; and by Section 3 of the Interpretation Act, 1889, the expression also includes "messuages, tenements, and hereditaments, houses, and buildings of any tenure," unless the contrary intention appears. By Section 108, a local authority may contract for, purchase, or take on lease, any lands, buildings, engines, materials, or apparatus for the purpose of receiving, storing, disinfecting, distributing, displacing, or treating sewage, subject to the terms of Sections 144 and 145 of this Act.

Arbitration.

Section 145 (11) relates to the ascertainment of compensation in cases where this is disputed, under an Order or Provisional Order made under earlier parts of this section (Subsection 4, etc.), and provides for the settlement by arbitration. The reference is to a single arbiter, who may be appointed by the parties, or if they do not so agree, then, on the application of either party, the appointment may be made by the Local Government Board for Scotland, at a remuneration to be fixed by the Board. Such arbiter shall be deemed to be a sole arbiter within the meaning of Sections 24, etc., of the Lands Clauses Consolidation (Scotland) Act, 1845, and its provisions with respect to an arbitration shall apply; the expenses shall be determined by such arbiter, notwithstanding anything to the contrary in the Lands Clauses Acts, and such determination shall be final. The arbiter shall hear any authorities or parties whose interest will be affected, by themselves or their counsel, or agents, and may hear any witnesses.

Purchase of Lands, etc., by Agreement and Compulsorily.

For certain special purposes (Part II. in relation to sanitary purposes, and Part III. sewers, drains, and water supply) set out in Sections 144 and 145, the Lands Clauses Consolidation (Scotland) Act, 1845, and the Amendment Act of 1860 are, by Sections 4 and 23 of the Interpretation Act, 1889, incorporated in the Public Health (Scotland) Act, 1897.

Under the 1845 and 1869 Acts, a curious omission was made, in that no provision was made in cases where land was not "taken" for the purposes of the particular work, but was nevertheless "injuriously affected" by its execution. It was not until the passage of the 1897 Act that this omission was rectified by Section 4 (2), which resulted in Sections 6 and 72-78 of the Railway Clauses Consolidation (Scotland) Act, 1845, being incorporated in this Act. For our purpose we are not concerned with Sections 72-78, which deal with mines in the vicinity of railways.

Purchase by Agreement.

Section 144 empowers a local authority, in terms of the Land Clauses Acts, to purchase lands by agreement or otherwise, whether *within* or *without* their district, and they may by agreement take on lease, sell, or exchange any lands similarly situated; or buy up any water-mill, dam, or weir, which interferes with the proper drainage of their district. With the sanction of the Local Government Board, the local authority may sell or let any surplus lands, as dealt with and defined by Sections 120-127 of the Lands Clauses (Scotland) Act, 1845.

Compulsory Purchase.

Section 145 (1) sets forth the regulations applicable to cases of *compulsory purchase* of lands, etc., under which the local authority have to advertise details of the proposed works, stating where a plan of the land to be taken may be seen, the quantity, etc., and also serve notices on the owners, occupiers, etc., of the property proposed to be acquired compulsorily before applying to the Local Government Board for an Order empowering its acquisition.

The advertisements must be inserted in a newspaper, circulating in the whole or part of the district where the work is proposed to be carried out, once at least in each of two consecutive weeks.

A notice, defining in each case the particular land proposed to be taken, must be served on every owner or reputed owner, lessee, or reputed lessee, or occupier, who should be requested to answer whether he assents, dissents, or is neutral regarding the taking of the land in question.

As regards "service" of the notice, this may be effected by personal delivery to the person on whom the notice is required to be served; or by delivery at his usual or last known place of abode; or by sending same thereto by registered letter.

The plan referred to above should be drawn to a scale of not less than four inches to a mile, and the book of reference to such plan, which should also be open to inspection with it, must contain the names of the owners or lessees, or reputed owners or lessees and occupiers of the lands which may be acquired compulsorily upon compliance with the above requirements of this section (145). The authority must, by Sub-section 2, if they wish to proceed further (though they may abandon the matter at this stage if they so desire), present a petition to the Board for permission to put in force the compulsory purchase powers of the Lands Clauses Acts with respect to the lands proposed to be taken. The petition must state the purposes for which required, and the names of the owners, or lessees, reputed owners, or lessees, and occupiers thereof who have assented to or dissented from the taking of such land, or who have returned no answer to the notice.

Upon receipt of such petition, and due proof of the advertising and service of the notices, the Board may after consideration dismiss the petition or order an inquiry in the district in which the lands are situated, or otherwise inquire as to the proposals of the local authority and as to the propriety of assenting to the petition; but until such inquiry has been made, after such notice as may be directed by the Board, no Order shall be made affecting any land without the consent of the owners, lessees, and occupiers thereof.

The inquiry may be held by a person appointed by the Board, if the Secretary for Scotland so directs in writing, or by the Sheriff, not being a sheriff-substitute resident.

The Board may, by Section 8, appoint some person or persons, not being a member or members thereof, to act as commissioner or commissioners for the purpose of conducting any special inquiry for a limited period, and to report thereon.

After the completion of the inquiry the Board may issue a Provisional Order authorising the authority to put in force the Lands Clauses Consolidation (Scotland) Acts, with respect to the acquisition under compulsory powers of the land, or any part thereof, referred to them, incorporating in the Order the said Acts, including (with the necessary modifications Section 6 of the Railways Clauses Consolidation (Scotland) Act, 1854, which rectifies an omission in the Lands Clauses Consolidation (Scotland) Act, 1845, as to the "injurious affection" of any property not "taken."

Following this, the local authority must serve a copy of the Board's Provisional Order upon the persons (owners, etc.) upon whom the notices, referring to the intention of the authority to acquire their lands, have been served, together with a statement that the Provisional Order will take effect as an Act of Parliament unless within two months a memorial is presented to the Secretary for Scotland praying that the said Order shall not become law without Parliamentary sanction.

The Bill for confirming any such Order, after second reading in the House (Lords or Commons) in which it originated, must be referred to a Select or Joint Committee. If within seven days of such second reading a petition is presented against any Order comprised in the Bill, the petitioner may appear and appeal personally, or by his agents and witnesses.

Any Act that may be passed to confirm such Order shall be deemed a public General Act.

The committee may by a majority award costs from the date of the memorial.

All costs, charges, and expenses incurred as regards any application for the grant of such Order, and to such amount as the Board directs, shall be a charge upon the Public

Health general assessment (under Section 135 of the 1897 Act) in districts other than burghs, and Section 136 in burghs, or the special sewer or special drainage district rates assessment (under Section 137), or Part I. of the Burgh Sewerage, Drainage, and Water Supply Act, 1901, where it is in force in place of that section.

Powers of Enforcing Entry on "Lands" for Various Purposes.

Section 109 provides for cases in which it is necessary to enter, examine, or lay open any lands or premises for the purpose of making plans, surveying, measuring, taking levels, examining work, ascertaining the course of sewers or drains, making or repairing, altering, or enlarging sewers or drains, etc., and if the owner or occupier of premises refuses or withholds access, the local authority may, after written notice under Section 159, apply to the sheriff, under Section 154, for a warrant for admittance for the purpose of the works at all reasonable times in the daytime (under Section 3) —9 a.m. to 6 p.m.

Power to Purchase or Construct Sewers and Carry Out Works for Sewage Disposal.

Power to purchase sewers is given local authorities by Section 102, subject to the provisions of Sections 144 and 145 (which deal with purchase by agreement or compulsorily), and they may acquire the rights and powers vested in any person to make sewers or to use any sewer, with or without the buildings and other things thereto pertaining, subject to paying compensation therefor, and also compensating the proprietors and occupiers of any lands and heritages for damage thereto. As regards the compensation, Section 164 enacts this shall be payable out of any fund or assessment applicable under this Act, "to all persons sustaining any damage by reason of the exercise of any of the powers of this Act, except when otherwise specially provided." It should be noted that this refers only to damages sustained "by reason of the exercise of any of the powers of this Act." As regards the ascertainment of the compensation, and in case of dispute, if the sum claimed does not exceed £50, either party may apply to the sheriff, whose decision shall be final and not subject to review. But where the compensation has been decided by the sheriff-substitute, the sheriff himself may review it in case of appeal. If the sum claimed exceeds £50, a sole arbiter appointed under Section 145 (11) of this Act shall determine the amount of compensation.

By Section 103, the local authority shall have power to construct *within* their district, and also when necessary for the purpose of outfall, or distribution, or disposal, or treatment of sewage, *without* their district, such sewers as they may deem necessary for keeping their district properly cleansed and drained; and for that purpose may carry them through, across, or under any public or other road, street, place, etc., or under any celler or vault, which may include the foot pavement or carriage-way of any street or road, and after reasonable notice in writing (if upon the report of a surveyor it should appear to be necessary), into, through, or under any lands whatsoever, and from time to time to execute thereto any works which may appear essential, but subject to no nuisance being created.

As to the case of any person being deprived of the lawful use of any sewer by the execution of such works, it shall be the duty of the authority to provide another, "sufficiently effectual for his use." The authority are bound to cause the sewers to be constructed, maintained, and kept so as not to be a nuisance, and, for the purpose of cleansing and emptying them, may construct and place all necessary reservoirs, sluices, engines, or other works, either above or under ground, and may, subject to the provisions of the Rivers Pollution Prevention Acts, cause such sewers to communicate with and be emptied into such places as may be fit and necessary, either within their district, or, *if necessary, for the purpose of outfall, or distribution, or disposal, or treatment of sewage without their district*, and to cause the sewage and refuse therefrom to be collected for sale, or for any purpose whatsoever, but so as not to create a nuisance. Provisions are made for the protection of any railway, canal, bridge, tunnel, or other work by Section 167; and Section 189 enacts that carrying out the provisions of the Act shall not affect the navigation of rivers or canals, or the irrigation of lands in rural districts, the supply of water for water-works, the purification of any river or stream, etc. As regards burghs, the authority may carry out drainage, etc., works under this section, or under the provisions of the Burgh Police Acts. As regards the execution of sewerage works *without the district*, Section 104 enacts that the authority must give three months' written notice prior to the construction of any sewer or sewerage works. The notice consists in advertising in one or more newspapers circulating in the district where the work is proposed to be carried out, and by posting handbills throughout the same district, describing the nature of the work and the intended termini, together with the names of the parishes and the public roads and streets and other lands (if any) through, across, under, or on which the work is to be made, and shall name a place where the plans of the intended work will be open for inspection during reasonable hours, and a copy of such notice shall be served on the owners or reputed owners, tenants, or reputed tenants, and occupiers of the said lands, and on the local authority and county council where such district is situated (which presumably means the district and county council within whose area the work is to be executed).

Power is given to the Public Works Loan Commissioners, by Section 142 (on the recommendation of the Local Government Board for Scotland), to lend money to local authorities for sanitary purposes, whether the works are, or are about to be, executed.

In case of objection by the local authority or county council, mentioned in Section 104, "or any owner, tenant, or occupier who would be affected by the intended work," notice thereof is, by Section 105, required to be served on the local authority at any time within the three months required by Section 104 for announcing the proposed work, and unless the objection is withdrawn, the work must not be commenced without the consent of the Local Government Board for Scotland, after the Board's Inspector has held an inquiry on the spot "into the propriety of the intended work and into the objection thereto," as provided by Section 106.

This inquiry may also be ordered by the Board on the application of the local authority proposing to carry out the work, and, on receiving the Inspector's report, "the Board may make an Order disallowing or allowing, with such modifications (if any) as they may deem necessary, the intended work.

Under Section 145, which applies to cases of compulsory purchase of lands, etc., the Board may, under Section 8, appoint some person or persons, other than any member of the Board, to hold any special inquiry thereunder. (In planning a system of sewerage, it is essential to bear in mind that the local authority may be called upon to provide for the admission to the sewers of the wastes from manufacturing processes as carried on in factories, etc., under

Section 110 of this Act and Section 7 of the Rivers Pollution Act, 1876.)

By Section 116, "The owners or occupiers of distilleries, manufactories, and other works shall be *compelled*, where *possible*, to dig, make, and construct pools or reservoirs within their own ground, or as near their works as possible, for receiving and depositing the refuse of such works, so as to prevent such refuse from becoming *offensive or injurious or dangerous to the health of those living in the vicinity thereof*, or, to use the best practicable means for rendering the same inoffensive or innoxious before discharging it into any river, stream, ditch, *sewer*, or other "channel."

This section should be read in conjunction with the Rivers Pollution Prevention Acts, 1876 and 1893.*

Estimates for Carrying out Work.

Where it is proposed to carry out any work connected with sewerage or drainage, if the probable expense will exceed thirty pounds, Section 113 enacts that the local authority shall procure from a surveyor an estimate of the probable cost of substantially constructing the same, and the yearly cost of keeping it in repair; and the surveyor is also to furnish a report as to whether the most advantageous mode of executing the work would be under a contract for construction only, or for maintaining in repair during a given term of years also.

(See also the Form II. required to be filled up for the Local Government Board for Scotland, where the local authority propose to borrow for the execution of sewerage works (p. 226), and the Burgh Sewerage, Drainage, and Water Supply (Scotland) Act, 1901, Part I. Secs. 1 and 2) (p. 289)).

Joint Sewerage Works.

When it may be for the benefit of the respective districts of two or more local authorities, they may combine for sewerage purposes. The sanction of the Local Government Board is necessary, and in applying for the Board's sanction, a joint application may be made by the authorities wishing to combine, or the Board may be approached at the instance of each of such local bodies.

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* See p. 291 *et seq.*

Section 121 regulates the manner of combining, and enacts that it shall be "for the purpose of executing or acquiring an interest in, or maintaining any works by this Act or any other Act authorised in regard to sewerage or drainage that may be for the benefit of their respective districts." This section would enable local authorities to combine for the purpose of purchasing or constructing sewers, and general works for the outfall or distribution, disposal or treatment of sewage under Sections 102 and 103.

The Formation of Special Drainage Districts.

Special drainage districts may be formed, enlarged or combined with others under Section 122, and for such a purpose a rural local authority may form a portion of their district into a separate area for the purpose of drainage. Any preliminary expenses incurred in the formation of a special drainage district are chargeable to the special assessment. These would include cost of surveys, Provisional Orders, etc., and also the salary of an official employed for the purpose of superintending joint sewage disposal works.

For the purpose of borrowing money for carrying out any works under this section, the provisions of Section 139 should be followed. No action relative to the formation or combination, etc., of special drainage districts may be taken without the sanction of the sheriff. Prior to this, the parish council of the particular parish within the district of a local authority, or not less than ten ratepayers, must make a requisition to the local authority, calling upon them to consider the propriety of taking steps for carrying out the formation or combination, etc., of part of their district into a special drainage area; or enlarging or limiting the boundaries of a special drainage district, or combining one such district with another, etc. The local authority shall then meet and determine by resolution "all questions regarding the payment of any debt which may affect any district or special drainage district, and the right to impose and the obligation to pay any assessment affected by such determination and shall fix the date at which such determination shall take effect." The resolution shall be published either by advertisement in one or more newspapers circulated within the district in question, or by the posting of handbills therein, and a copy of such resolution shall be transmitted to the Board, or, when the local authority is a district committee, to the county council.

Any person interested may appeal to the sheriff against the resolution within twenty-one days of its application, who may either approve or disapprove of such resolution, and may either decide that no special drainage district shall be formed, or may enlarge or limit the special district as defined by the authority's resolution, or may find that the area or part thereof should be combined with another, or that any such combination should cease, and his decision shall be final. If a sheriff-substitute makes the announcement, an appeal against it may be made to the sheriff.

The order of the sheriff shall determine all questions as to the payment of debts affecting any district or special drainage district, and also in relation to the imposition, and obligation to pay any assessment affected by his determination. A copy of any such sheriff's order shall be forthwith published in one or more local newspapers, or by the posting of handbills in the district, and also to the Local Government Board and the county council.

Powers of Utilising Sewage.

For this purpose the local authority may either undertake works on their own account for the application of sewage to land, or, by Section 108, may agree with any person to supply such sewage, or as to its distribution or disposal or treatment over land, and as to the works to be made for such purpose. The terms of agreement may fix the parties who are to carry out the same and to bear the cost thereof, and also as to the amount, if any, to be paid for the supply of sewage.

A contract for the supply of sewage shall not be made for a period exceeding five years, without the authority of the Board, and not for any period exceeding twenty-five years. For a lesser period than five years the consent of the Board is not required, though one for an indefinite period would not appear to be valid.

In cases where lands are held by owners of limited interests, and works of distribution and service for the supply of sewage to lands for agricultural purposes are undertaken thereon under Sections 103 and 108 of this Act, they shall be deemed an improvement of land authorised by the Improvement of Land Act, 1864, under which such owners may execute certain improvements and charge the land with the cost.

APPENDIX G.

The Burgh Sewerage, Drainage, and Water Supply (Scotland) Act, 1901.

The object of this Act, which has also been dealt with where it applies under other legislation, was to amend the law in regard to the sewerage and drainage (and water supply) of Scottish burghs, especially as regards borrowing money for the carrying out of either such undertakings; whether the money was borrowed before this Act came into operation in such burgh, under any Act providing therefor, or after the passing of this Act (17th August, 1901); and also with regard to the payment of such principal money and interest, by means of a sewer (or water) assessment, upon which either such sums may constitute a charge. In respect of these sums the creditors shall have "all the powers, rights, and remedies, at the passing of this Act, exercisable by a lender of money" (Sec. 1).

This Act shall *not* apply (1) to any burgh to which the Burgh Police (Scotland) Act, 1892, does not apply; (2) to any burgh in which, at the passing of this Act, a local Act (including an Act confirming a Provisional Order) is in force, with respect to sewerage and drainage (and water supply).

But in either of such cases the town council of the particular burgh may pass a resolution to "adopt" Part I., which relates to sewer assessments becoming security for sums borrowed for sewerage and drainage, and communicate such resolution to the Secretary for Scotland (Sec. 8).

The town council of any burgh under the Burgh Police (Scotland Act, 1892, have conferred upon them, in addition to powers as to sewers and drainage (and water supply), the same rights and privileges in relation thereto as are conferred by the Public Health (Scotland) Act, 1897, upon local authorities under that Act in districts *other than burghs*. Such powers, etc., shall extend to the whole area of the burgh under the 1897 Act.

Where in any special or separate drainage district drainage works have been executed and maintained therein, lands and heritages therein shall not be liable for assessment in respect of sewerage and drainage works in other parts of the burgh (Sec. 2).

The sewer assessment, together with the water assessment, shall not exceed the rate of four shillings in the pound, except with the permission of the Local Government Board for Scotland (Sec. 2).

Where the provisions of the 1901 Act apply, Sections 233, 236, and 363 of the Burgh Police (Scotland) Act, 1892, shall be read as if the sewer "assessment" under the 1901 Act were substituted for the sewer "rates" mentioned therein (Sec. 4).

APPENDIX H.

The Rivers Pollution Prevention Acts (United Kingdom).

The subject of the fouling of the waters of rivers, streams, and other watercourses, is one to which considerable attention has been given for many years past. Their pollution has been caused in many ways; but the three chief causes have resulted from the discharge of sewage and manufacturing and mining wastes. It was the highly deleterious results which accrued from these discharges which brought forth legislative action in the shape of the Rivers Pollution Prevention Act of 1876. As has been noticed, the pollution of water by the entry of crude or imperfectly "treated" sewage still continues to be a matter of considerable import. Especially is this so in relation to those streams which furnish potable waters, and the æsthetic side cannot be lost sight of, for a foul stream of water will certainly spoil the amenities of any district through which it flows.

Elsewhere we have commented on the fact that so far the requirements of the 1876 Act have been in advance of present-day scientific knowledge. Previous Commissions have endeavoured to deal with the matter on practicable lines, but without any workable results. The next Report of the Fifth (and present) Royal Commission, which it was hoped would be issued in May, 1911, as the Secretary to the Royal Commission was kind enough to tell the writer, is intended to deal in part with this aspect of the subject.

The Rivers Pollution Prevention Acts, 1876, 1893, and 1898.

These Acts have been referred to in different parts of our subject, upon which they have considerable bearing. They were intended to have a wider application than their titles would convey, because Section 20 of the 1876 Act has a very wide meaning of the word "stream."

The 1876 Act was passed with a view to preventing the pollution of "rivers," and more particularly to prevent new sources of pollution, for it may be remarked in passing that it used to be no uncommon practice to turn crude sewage and other noxious matters into streams of water—and this is by no means yet a thing of the past.

The Public Health Acts had previously contained sections aimed at preventing the pollution of watercourses, etc., by local authorities, but not against any manufacturer, mine owner, or private individual. The discharge of sewage and other noxious matter by such persons, however, comes under the provisions of these Acts.

Rivers Pollution Prevention Act, 1876.

This measure applies, with slight difference, chiefly in connection with the administration of the Law, to the United Kingdom.

As regards the pollution (which does not, by Section 20, include innocuous discoloration) of any stream, or interference with its due flow, by the putting of solid matters therein ("solid matter" does not, by Section 20, include particles of matter in suspension), repetition of the acts may be taken together to prove the offence if necessary. The solid matters may consist of any rubbish, the refuse from a manufactory or quarry, etc., or any putrid solid matter (Section 2).

Part II. deals with the law as to pollution from sewage, whereby it is prohibited to discharge sewers into "streams" (Section 2).

The Public Health Acts (1875, Section 17, and 1878 (Ireland), Section 19) prohibited sanitary authorities from discharging sewage or filthy water into any natural stream, or watercourse, canal, pond, or lake, until "freed from all excrementitious or other foul or noxious matter such as would affect or deteriorate the purity and quality" or such water. But it was not till this Act that *every person* was made similarly actionable (Section 3). Any such person who passes sewage matter through a drain which communicates with a local authority's sewer, which discharges into a stream, is not actionable if he does so *bonâ fide*. The onus in such cases rests on the authority.

Part of this same section was by no means clearly set out, and it was not until the Rivers Pollution Prevention Act, 1893, that the necessary explanation was given. That Act consists of only two sections. The working part is Section 1, as follows :—

"Where any sewage matter falls or flows or is carried into any stream, after passing through or along a channel which is vested in a sanitary authority, the authority shall, for the purposes of Section 3 of the Rivers Pollution Prevention Act, 1876, be *deemed to knowingly* permit the sewage matter so to fall, flow, or be carried" (Section 1).

Returning to the 1876 Act, by Section 7 the sanitary authority must give facilities for drainage to carry away liquids from manufactories, unless their sewers are only sufficient for the requirements of their district, or unless such liquids would prejudicially affect them, or would from their temperature or otherwise be sanitarily injurious, or would affect the disposal by sale, application to land or otherwise of the sewage matter.

As regards the pollution of streams, the local authority are empowered to institute proceedings in the local county court or analagous court. They may also proceed against any other sanitary authority or person causing the pollution within their own district of any stream, whether such pollution is caused within or without the area of the prosecuting authority.

Similar proceeding may also be instituted by a private individual "aggrieved by the commission of such offence" (Section 8).

This latter would apply in a case where a local authority discharged imperfectly purified sewage into a stream or water-course, and the liability is transferred from one authority to their successors, as in the case of a board of guardians, who had constructed a sewerage system, having their powers transferred to a rural district council, and subsequently to an urban district council by an Order of the Local Government Board.

As we have noticed, a private person is empowered to obtain an injunction where a local sanitary authority allows sewage to escape from their sewage system, and foul a natural stream of water where he is a riparian owner having an inherent right to the flow of water past his land in its natural state of purity, free from any noxious matter discharged into it by any person, including a sanitary authority.

Rylands v. Fletcher (1868), L. R. 3 H. L. 330 is an important case on the point, as is also the recent case of Jones v. Llanrwst Urban District Council (January 20th, 1911)* in which a riparian owner obtained an injunction against an urban council, who polluted a stream by allowing sewage to escape from a sewerage system constructed by a board of guardians, whom they succeeded.

* Surveyors' Institution Professional Notes, vol. xvii. (1911), p. 186, Part II.

The county court has power to restrain the commission of the offence, or to make such order as seems meet, or prior thereto may remit to "skilled parties" to report on the "best practicable and available means," and the nature and cost of the works and apparatus required, "who shall in all cases take into consideration the reasonableness of the expense involved in their report" (Section 10).

Either party aggrieved may appeal to the High Court (in Scotland, the Court of Sessions; in Ireland, the Superior Courts). The county court judge (or the equivalent in Scotland or Ireland) may at the outset remit the case to the Higher Courts (Section 11).

The county court may enforce the carrying out of its order by appointing a person to carry it into effect, if the defendant neglects to do so within the time prescribed by the order, or for not less than a month from its issue. The same court may also impose a penalty, not exceeding £50 a day for every day during which there is default (Section 10).

Where an authority discharges sewage under a special Act of Parliament into the sea or any tidal waters, no infringement of this Act is involved (Section 19).

The Local Government Board may appoint an inspector of "proper qualifications," who may grant a certificate "that the means used for rendering harmless any sewage matter or poisonous, noxious, or polluting solid or liquid matter falling or flowing or carried into any stream, are the *best or only practicable and available means* under the circumstances of the particular case."

The inspector may fix the time, not exceeding two years, during which the certificate shall remain in force, after which it may be renewed for two years or less. The certificate shall be "conclusive evidence of the fact" in all courts and proceedings under this Act. An appeal in respect to the certificate may be made to the Local Government Board. The applicant for the certificate pays all costs incidental to obtaining it (Section 12). The Board may make orders relative to their costs in the inquiry (Section 14). Inspectors may examine witnesses and call for the production of papers, etc. (Section 15).

Proceedings with reference to sewage, manufacturing and mining pollutions, must not be taken unless the offender has been given two months' previous notice thereof. Action under this Act must not be taken while other proceedings in relation to the same offence are pending (Section 13).

Meaning of "Stream."

The expression "stream" has a very wide meaning. By Section 20 it "includes the sea to such extent and tidal waters to such point as may, after local inquiry and on sanitary grounds, be determined by the Local Government Board, by order published in the "London Gazette" (or that published in Edinburgh or Dublin). Save as aforesaid, it includes rivers, streams, canals, lakes, and watercourses other than watercourses at the passing of this Act mainly used as sewers, and emptying directly into the sea or tidal waters which have not been determined to be stream within the meaning of this Act by such administration of the Act as aforesaid."

Part IV. refers to the administration of the Act, under Section 7.

Sanitary authorities are to give facilities to enable manufacturers within their district to carry liquid wastes from their factories into the local sewers, provided that the local sewage be not prejudicially affected thereby, nor the sewers merely sufficient for the requirements of the district in question. Otherwise there appears no compulsion.

Section 8 empowers every sanitary authority (subject to the restrictions contained in this Act) to enforce the provisions thereof in relation to any "stream" passing through or by any part of their district.

Legal Proceedings.

Section 10. Offences may be restrained by summary order of the county (or analagous) court having jurisdiction in the particular district where the offence was committed, and may make such order as in its opinion seems fit, and, if it appears desirable, may, before granting such order, remit the case "to skilled parties to report on the 'best practicable and available means,' and the nature and cost of the work," etc.

An appeal to the High Court from a decision of the County Court is permitted.

Section 12. A certificate granted by an inspector of the Local Government Board that, in the circumstances of a particular case, the means used for rendering harmless any matter, etc., are the best available, shall be conclusive evidence of the fact.

"Solid matter" shall not include particles of matter in suspension in water.

"Polluting" shall not include innocuous discoloration.

"Sanitary authority" means the borough, urban, or rural district, council in England, Wales, and Ireland, and the analagous authority in Scotland.

As to Manufacturing Pollutions, Section 4 to 7 deal with the pollution of streams by manufacturing and mining wastes, and are in similar terms to Section 3, save that the sanction of the Local Government Board must be obtained to a prosecution by the local sanitary authority, and the Board in giving or withholding consent must take into consideration the industrial requirements of the district. If the proceedings are proposed to be taken by the sanitary authority of any district which is the seat of any manufacturing industry, the Board's consent should be withheld until an inquiry has been held, and the Board are satisfied that means are practicable and available for rendering harmless the poisonous, noxious, or polluting liquids proceeding from such manufacturing process, and that no material injury will be inflicted on the interests of the industry by such legal proceedings.

Facilities are also to be given by local authorities having sewers under their control, to enable manufacturers within their respective districts to carry the liquids produced in the manufacturing processes there carried on into such sewers.

There is an important proviso to this, however, that no authority shall be obliged to admit into their sewers any liquid which would prejudicially affect such sewers, or the disposal by sale, application to land or otherwise of the sewage matter conveyed along them, or which would be in any way injurious from a sanitary point of view.

The Rivers Pollution Prevention (Border Councils) Act, 1898.

This Act applies to cases where a river or tributary is situate partly in England and partly in Scotland, and (Section 1) enables the Local Government Board for England and Wales and the Secretary for Scotland, on the application of the councils of the counties concerned, to act together in the constitution of a joint committee or other body representing all or any of the counties through or by which such river, tributary, or any portion, passes, and may confer on such committee, or body, all or any of the powers of a sanitary authority under the Rivers Pollution Prevention Act, 1876.

By Section 2, Section 297 of the Public Health (England and Wales) Act, 1875 (relating to the making of Provisional

Orders by the Local Government Board) is, for the purpose of its application to such a case as above described, amended, so as to include the Secretary for Scotland as well as the Local Government Board for England and Wales.

APPENDIX I.

Some Notes on the Law of Drains and Sewers.

(UNITED KINGDOM.)

In a work of this kind, in which have been included notes on the many Acts of Parliament which regulate works for sewerage, the treatment of sewage, etc., and on drainage, it may be useful to offer a few remarks on the subject of "drains" and "sewers," from the legal standpoint.

For many years past the heavy litigation, which has followed the uncertainty in the interpretation of the law relating to the matter, has caused authorities in England and Wales to obtain private Acts to deal with the question so far as it affected their respective districts, with a view to getting rid as far as possible of the state of chaos which the general Acts (including those applicable to the London County Council area) had caused.

As regards England and Wales (outside the area under the control of the London County Council) the provisions of the Public Health Act, 1875, apply. In Ireland, the Public Health (Ireland) Act, 1878, is, so far as this subject is concerned, the same as the 1875 Act.

As regards the legislation with reference to this subject operative in Scotland, neither the Burgh Police Acts of 1892 or 1903, nor the Public Health Act, 1897, defines the expressions "drain" and "sewer." In some parts of each Act some allusion is made to both words.

It has been customary, however, to take the definitions set out in the Public Health (England and Wales) Act, 1875, Section 4, by which and by Section 2 of the Irish Act of 1878, "drain" means "any drain of and used for the drainage of *one* building only, or premises within the same curtilage, and made merely for the purpose of communicating therefrom with a cesspool or other like receptacle for drainage, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed."

"Sewer," on the other hand, "includes sewers and drains of every description, *except* 'drains' to which the word 'drain' interpreted as aforesaid applies, and except drain vested in or under the control of any authority having the management of roads, and not being a local authority under this Act." As regards the London County Council area, under the Metropolis Local Management Act, 1855, and its amendments, the definition is almost the same; "drain," however, includes any drain for draining a group or block of houses, i.e., combined with others, under the order of any vestry or district board (now Metropolitan Borough Councils), or with the sanction and approval of the Commissioners of Sewers (since 1898, the City of London Corporation).

A recent case in the High Court, London ("House Property and Investment Co., Ltd., v. Grice, Sanitary Inspector of the Metropolitan Borough Council of Bermondsey,") April 6th, 1911, illustrates a case in which the question of the sanction of a London Borough Council to the construction of a "combined" drain arose. The case was one stated by a Metropolitan Police Court Magistrate. It was proved by the production of the account book of the Bermondsey Vestry (the predecessors of the Council) that an entry had been made therein of the amount named by the surveyor as having been paid to the vestry in connection with the construction of the short length of drain pipe, which had been sanctioned by the vestry in 1858 as a "combined" drain for draining eleven houses.

This effectively disposed of the Company's contention that the pipe was a "sewer," and hence the Sanitary Inspector had been right in 1910 in serving a notice on the appellants in respect of the defective line of pipes in question. "Drains" are generally maintained by private owners.

"Sewers," on the other hand, are vested in and repaired by the local sanitary authority out of the rates, hence the importance of having the legislative provisions in connection as definite as possible.

In the ordinary acceptation of the term, "drains" would be considered to mean pipes laid usually underground, and used for the conveyance of waste waters and general sewage matter from baths, sinks, water-closets, etc., from the house and its precincts into the public conduits or sewers; also for rain-water or agricultural drainage. "Sewers" in like manner would be taken to mean the larger conduits, similarly laid under streets and roads, to which the house-pipes are connected for the purpose of conveying the foul matter from the various houses and premises on the route to some place for discharge or "treatment."

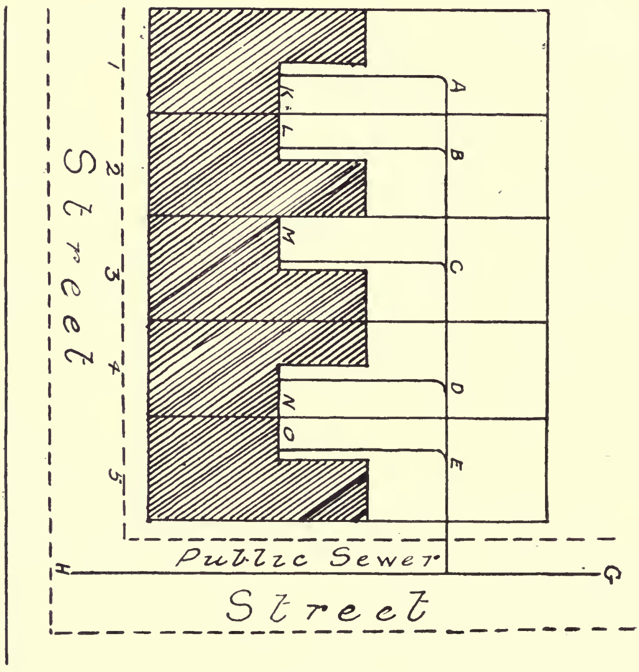

Fig. 52.

Plan illustrating the law of Drains and Sewers.

But these commonplace interpretations are not such as should be placed upon the expressions "drain" and "sewer" when used in a legal sense under Acts of Parliament. A sketch (Fig. 52) will, perhaps, assist in explaining the foregoing definitions. It shows a terrace of five houses. The pipes (4 in.) from each separate house, are carried out into the back gardens, and there communicate with a larger pipe (AF) of 6 in. or 9 in. diameter, running under each garden, and in its turn joining the main conduit (GH) in the side roadway. Now, according to the preceding definitions, the pipes AK, BL, CM, DN, EO, are "drains," and, therefore, repairable at the cost of the respective owners; whilst the larger pipe (AF) is also a drain, from where the pipe from the first house joins it at A, to B where the pipe from the second house makes a junction with it; after which it is a "sewer" as much as the pipe (GH) in the public roadway. If in the London Metropolitan area, however, it may be a "combined" system of drainage for the block of buildings sanctioned or ordered by the sanitary authority.

As we shall notice more fully later, litigation under the 1875 Act with reference to the vexed question of the respective rights and liabilities of owners and local sanitary authorities with regard to drains, was of frequent occurrence. With the object, therefore, of simplifying matters in England and Wales, outside the London County area, a Section (19) was inserted in the Public Health Acts amendment Act, 1890, which was intended to be read as one with the definitions of drain and sewer in Section 4 of the 1875 Act, and Section 2 of the Public Health (Ireland) Act, 1878. Though it may have attained its object in a few instances, generally speaking it has only made matters more confused. Again, it is only an "adoptive" Act, and not like the parent Acts of 1875 and 1878, a compulsory one. It is therefore only applicable to districts where Part III., containing chiefly the sanitary provisions of the Act (including Section 19) has been "adopted" by the local sanitary authority in accordance with the method laid down in the Act (Section 3) under which both urban and rural authorities are empowered to "adopt" the same, forwarding then a copy of the "adoption" to the Local Government Board either in London or Dublin.

Section 19 of the 1890 Act enacts that where two or more houses belonging to *different owners* are connected with a public sewer by a *single private drain*, an application may be made under Section 41 of the Act of 1875, and by Section 12 of this Act, Section 51 of the Public Health (Ireland) Act, 1878 (which relate to complaints as to nuisances from drains, and the procedure to enforce their amendment, and the execution of the necessary works, in default, and the recovery of expenses), " and the local authority may recover any expenses incurred by them in executing any work under the powers conferred on them by that Section " (41 of the 1875 Act, and Section 51 of the 1878 Act) " from the owners of the houses in such shares and proportions as may be settled by their surveyor, or (in case of dispute) by a court of summary jurisdiction " (i.e., a police court). For the purposes of this section (only) " the expression ' drain ' includes a drain for the drainage of *more than one building*," which, for all other purposes, would be a " sewer." If not inconsistent with the context, the expressions " drain " and " sewer " have the same meaning as given in the Act of 1875 (Section 4) and the 1878 Irish Act (Section 2).

By Section 41 of the 1875 Act and Section 51 of the 1878 (Ireland) Act, the " complaints as to nuisances from drains " must be " on the written application of any person to a sanitary authority," stating that any drain, water, or earth closet, privy, or cesspool is a nuisance, or injurious to health (but not otherwise)."

Section 34 of the Public Health Acts Amendment Act, 1907, which, like the 1890 Act, applies to England and Wales and Ireland (outside London), and is likewise an " adoptive " measure, extends the provisions of the above-mentioned sections, by enacting that they shall have effect, as if for the words (" but not otherwise ") there were substituted the words, " or where on the report in writing of their surveyor or inspector of nuisances the local authority *have reason to suspect* that any such *drain*, water-closet, earth-closet, privy, ashpit, or cesspool is a nuisance or injurious to health."

Unfortunately, no definition was given in the 1890 Act of the meaning of the expression, " single private drain," nor has it yet been satisfactorily defined. Different judges before whom cases have come for decision involving its consideration have given many and varied decisions. One or two have frankly admitted inability to give any kind of reason for the decisions at which they have arrived. With a view to noticing the effect which the " adoption " of Section 19 of the 1890 Act, dealt with above, has produced, and again referring to the sketch (Fig. 52), we find that, where in force, if two houses belong to the *same* person, the combined drain is a "sewer," and as such repairable by the local authority; but if the same two houses are the property of *different* owners, then the combined drain is a "drain," and any expenses incurred in repairs or renewal fall upon the respective owners.

Though it is not intended in these pages to discuss pros and cons, it may be remarked that it is manifestly unfair that a person owning several houses is not as responsible for his proportion of the expenses incidental to a "combined" drain serving his property as the owner of a single house would be in the circumstances mentioned.

Another point in the 1875 and 1878 Acts requiring definiteness is the meaning of "curtilage." Varied interpretations have been given by different judges in the Courts of England and Wales. Perhaps a fair and reasonable definition is "the land adjoining a building, and which would pass on a conveyance with it as being necessary and convenient for its use." Also, what is "one building only"? Apparently it is indefinable. In each case it is a question of fact, for, according to a judge's decision, "no general rule can be laid down as to whether a pair of semi-detached houses are 'one building only,' within the meaning of Section 4 of the 1875 Act, or not, even though they are under one continuous roof."*

"Combined drainage" constitutes a continued source of litigation, both in London and the provinces. In London, if a drain, either in ignorance or surreptitiously, is connected up to another drain the latter becomes a "sewer," and as such is maintainable by the local sanitary authority. Even subsequent disconnection has been decided by the court (in a case where two houses had been drained together without an order from the authority) not to convert the pipe from a "sewer" to a "drain."

The connection of a rain-water pipe used for the conveyance of rain-water from two houses into the drain of one house has been held by the Court of Appeal to constitute such drain a "sewer," and therefore repairable by the local sanitary authority.

To illustrate the unsatisfactoriness of the expression "single private drain" under Section 19 of the Act of 1890 previously alluded to, we have three important cases the

* Humphreys v. Young, Div. Ct., K.B.D. (1903), 144.

decisions in which (one of the House of Lords and another of the Court of Appeal) do not serve to simplify matters. In the House of Lords' case, Urban District Council of Wood Green (appellants) v. Joseph (respondent)*: There were several houses the property of different owners which stood in a row and were drained in pairs; each house of each pair was drained by a separate pipe into a pipe which was common to both houses, and each of these common pipes discharged itself into a line of pipes laid in private ground, which discharged into a public sewer. It was admitted that the "common pipes" were "sewers" within the meaning of Section 4 of the Public Health Act, 1875 (Sec. 2 of the Public Health (Ireland) Act, 1878). It was held that the "line of pipes" which discharged into the public sewer was not a "single private drain" within the meaning of Section 19 of the Public Health Acts (Amendment) Act, 1890, and therefore that proceedings could not be taken under that section, and Section 41 of the Public Health Act, 1875 (Sec. 51 of the Public Health (Ireland) Act, 1878).

In the appeal case, Jackson (appellant) v. Wimbledon Urban District Council,† the owner of certain houses had been called upon to pay for some repairs to a pipe which was laid in the rear of several houses, and received the drainage of each (similar to Fig 52), but which joined another pipe at right angles thereto, which latter pipe discharged into the public sewer in the roadway. The pipes in question (similarly to the previously quoted case) were situate on private property, and the "combined drain" was held to be a "sewer," whilst the pipe connecting this common or combined drain with the public sewer in the road remained a "single private drain." Hence two "sewers" (the public sewer and the common drain pipe), repairable by the local sanitary authority, are here connected by a "single private drain," repairable by the owners of the property.

In the third case, Thompson v. Eccles Corporation,‡ it was decided that neither the fact that the single pipe which drained two or more houses was wholly situate on private land, nor that the houses belonged to different owners, sufficed to make the pipe a "single private drain" within the meaning of Section 19 of the Public Health Acts (Amendment) Act, 1890.

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* L. R. (1908), H. L., 419.

† 1905, L. R., 41.

‡ Div. Ct. (1904), K.B.D.

Other cases, many of them contradictory in the judicial decisions, could be quoted to show the generally unsatisfactory state of the law on "drains and sewers." The Public Health Acts Amendment Act, 1907, which is applicable to England, Wales, and Ireland, is only an "adoptive" Act; under it, however, no alteration was made in the law bearing on this subject. The sanitary authorities of several important areas, including the London County Council, have sought powers by including various provisions in private Bills promoted by them, with a view to rendering the law under the general Public Health Acts less involved. The endeavours of the London authority have been, so far, without success. Among the successful authorities may be mentioned those of Bristol, Carlisle, Croydon, Sheffield, West Ham, and Wood Green. It may be of some interest to quote here part of a section of the special Bristol Act of 1905, which bears on this subject:—

"For the purposes of this section, the expression 'drain' includes any sewer or drain, whether constructed before or after the passing of this Act, with which two or more houses or premises (whether belonging to the same or different owners) are at the date of the passing of this Act, or may at any time hereafter be connected, or which is used or capable of being or intended to be used for the conveyance of the drainage of such houses or premises directly, or by means of any other sewer or drain, to any public sewer situated under a street repairable at large; but shall not include any sewer which has been constructed to the satisfaction of the Corporation under Section 150 of the Public Health Act, 1875, or any sewer which has been constructed by the Corporation for the effectual drainage of the city."

Under the above-mentioned section (150) power is given to compel the owners or occupiers of premises fronting, adjoining, or abutting on such part of any street within any urban district (not being a highway repairable by the inhabitants at large) which may require to be sewered, levelled, paved, etc., to do the necessary work.

(Similar powers are given under Section 28 of the Public Health (Ireland) Act, 1878.)

As regards the terms of the alterations in the law so far as it affects the area under the administration of the London County Council, a special committee of the London Metropolitan Borough Councils held several meetings in 1908, with the object of framing such provisions for embodying a Parliamentary Bill, to be promoted by the County Council, with a view to putting the law on "drains and sewers," so far as it relates to London, on a more workable basis. The Metropolitan Sewers and Drains Bill, 1908, which, however, did not receive legislative sanction, was as follows:—

"In and for the purposes of the Metropolis Management Acts, 1855 to 1899, and the Public Health (London) Act, 1891, or any Act or Acts amending the same, the word 'drain' shall be deemed to include any sewer or drain, whether constructed *before* or after the passing of this Act, with which *two or* more *houses*, buildings, or premises are, at the date of the passing of this Act, or may at any time thereafter be connected, or which is used or capable of being or intended to be used for the conveyance of the drainage of such houses, buildings, or premises, *directly or indirectly*, to any sewer which has been approved as such by the Metropolitan Board of Works, or the London County Council, but shall not include any sewer so approved as aforesaid."

It will be noticed that the provisions of this Bill were intended to relate to "*combined* drainage."

The salient features of the measure are here italicised.

The existing state of the law as regards sewers and drains certainly calls for amendment, because as the general law now stands it is the cause of almost endless litigation, and the consequent expense bears hardly upon many property owners. What appears to be needed is a short Act which should deal with the chief points of dispute under existing measures. The opinions of those judges of eminence who have expressed opinions on the various phases of the subject should be taken into consideration in framing such a Bill, as well as the views of different professional bodies, and its provisions should be made compulsory and generally applicable.

APPENDIX J.

Application of the Lands Clauses Consolidation Acts (United Kingdom).

The Lands Clauses Consolidation Acts of 1845 were passed to regulate the acquisition of land, and any property standing thereon, for the purpose of public or semi-public purposes. As regards this present subject, their provisions would apply to the taking of land, etc., for the purpose of constructing sewage disposal installations and works incidental thereto, and such provisions are used in conjunction with powers conferred on local sanitary authorities under the Public Health Acts.

The Lands Clauses Consolidation Act, 1845, applies to England, Wales, and Ireland. With regard to Scotland, the Lands Clauses Consolidation (Scotland) Act, 1845, is in many respects similar. The differences are largely those relative to legal matters, of rights or interests in lands, and in the various duties, and other charges, burdens, or incumbrances thereon. The various differences are set out as footnotes as they occur in the text*

Among the definitions in the Lands Clauses (England, Wales, and Ireland) Act, 1845, the following may be useful :—

"Lands" includes messuages, lands, tenements, and hereditaments of any tenure.

"Lease" shall include an agreement for a lease.

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* The Land Clauses (Scotland) Act, 1845. Interpretations of some expressions :—

"Lands" shall extend to houses, lands, tenements, and heritages of any description of tenure.

"Lease" includes a missive of lease.

"County" shall include any ward or other like division of a county.

"Sheriff" shall include the sheriff-substitute.

"The Bank" shall mean any one of the incorporated or chartered Banks in Scotland.

With these, and the alterations following, it is hoped that the procedure summarised in the notes on the Lands Clauses (England, Wales and Ireland) Acts, 1845, will be sufficiently clear in the application of like provisions to Scotland.

"Month" shall mean calendar month.

"Sheriff" shall include under-sheriff or other legally competent deputy, if such other official be interested in the matter in dispute.

"Bank" means the Bank of England, if the money to be deposited is in respect of lands situate in England or Wales; if in Ireland, the Bank of Ireland.

Sale and Purchase by Agreement.

The local authority should serve "notices to treat"* on all the parties interested as owners and tenants, stating particulars of the lands required, and requesting information as to their various interests therein, and as to the various claims made in respect thereof.

An agreement can be entered into for the sale to the authority of the required lands, where the interested party is absolutely entitled, for a monetary consideration, or if preferred, an annual rent-charge† payable by the authority can be agreed upon. Where, however, the person concerned as vendor is only tenant for life of the land or building, or is acting as guardian, trustee, executor, or administrator, etc.,‡ he is empowered to sell and convey under agreement; but the compensation has to be settled in a particular way—by two surveyors,§ one to be appointed by each party, and failing their agreeing, by a third surveyor appointed by two justices (in Scotland by the sheriff or sheriff-substitute). It should be mentioned in this connection that if a surveyor happened to be a trustee or guardian or to occupy a similar fiduciary position, he could not be appointed to fix the compensation payable.

(The latter case does not appear to be provided for in the Scottish Act.)

The compensation may be in the form of an annual rent-charge‖; or if a lump sum of money amounting to or exceeding £200, it has to be deposited in the Bank of England, or Ireland, depending on where the property is situated, in the names of persons interested. It can be

* Notices for the owner shall be served on the factor or agent (if any) if the owner is absent from the United Kingdom, or cannot be found.

† Feu duty, or ground annual.

‡ Persons under disability include heir of entail, life-renter, tutor, curator.

§ Styled valuators in the Scottish Act.

‖ Feu duty, ground annual, etc.

applied to the redemption of land-tax, the discharge of any debt affecting such land, the purchase of other lands, the repair of any building damaged through the execution of the scheme, and for similar purposes. If the compensation exceeds £20, but not £200, it may be similarly applied, or paid into the Bank of England or Ireland,* or to two trustees to be nominated by the persons entitled to the rents and profits of the lands. Should less than £20 be involved, it will be payable to the persons similarly entitled, or their guardians, or trustees, etc., as the case may be. With regard to the sum paid into the Bank or to the appointed trustees, if a tenant for life is concerned, he may be allotted a portion of it to recompense him for any injury which he may have sustained, independently of the actual value of the land taken.

The Compulsory Taking of Land.

The authority serve upon all persons of whom they have cognisance, interested in the particular lands and any houses or other buildings to be compulsorily acquired, what is known as "a notice to treat." This states particulars of that for which the authority will treat and pay compensation, and further requests the person to send details of his personal interest in the land or buildings, and a claim for compensation for the acquisition. Every lessee and tenant is entitled to compensation according to his interest.

The fact of a "notice to treat" being served makes further procedure under it compellable, and from its date the particular person's interest is fixed, and it is on such interest that the compensation should be based. Should the notice refer only to "part" of a house, building, or manufactory, as the case may be, however, the owner is entitled to serve an intimation on the authority, called a "counter-notice," informing them that the whole of the property in question must be taken—assuming he is willing and able to sell the same.

The counter-notice gives the compelling party the option of withdrawing from the matter; if not, the whole must be acquired.

There is a growing tendency for new Parliamentary Bills, brought in by the promoters of a scheme involving the acquisition of different properties, to contain a clause specially exempting the authority promoting the under-

* In Scotland any one of the incorporated or chartered Banks.

taking from liability where "part" of a house, building, etc., is concerned, especially where no material damage is likely to be caused by the severance. The London County Council, as an instance, had such a clause in a recent Bill before Parliament.

As to what is the meaning of "part" of a house, building, or manufactory, as the case may be, it would depend largely upon the circumstances of each individual case, and its solution has repeatedly led to litigation. In a common example, a portion of a garden would be "part of a house." A back way to a house through an adjacent field would possibly come under the same definition.

Further, if any land not in a "town" (i.e., a space in which houses are continuous) or built upon, be so cut and divided by the works as to leave on one or both sides less than half an acre, on request by the owner the authority have to purchase this land as well, unless the owner has other land adjoining that so left, into which it can be thrown so as to be conveniently occupied with it. Then, if the owner so wishes, the promoters of the undertaking, at their own expense, are to remove the fences, or level the site, or execute any other work necessary to connect up the different portions of land. There is a proviso, however, that if the cost of doing the necessary work for the connection exceeds the value of the piece of land to be joined up, the authority may insist on purchasing it also.

The Claim.

The owner, or other interested person, on receipt of the notice to treat, may within twenty-one days either send in his claim for compensation, together with the particulars asked for, or refrain.

Considerable care is necessary in framing the claim, which must be for a gross amount, to include *every* item for which recompense is claimed. There, of course, professional skill is essential.

The items claimed for by an owner or a person in a fiduciary position (as guardian, trustee,* etc.) will be the value of the land, house, or buildings to be acquired; also for any decrease in value which the remaining property (if any) will suffer by reason of the work, or for the interference with any right in connection. The future possibilities of the land, such as any chance of its being required

* Life-renters, judicial factors.

for house-building for instance, should enter into the claim, as should also its special adaptability for the particular purpose for which it is to be acquired. For example, the near presence of a quick-flowing stream of water to the land to be acquired for sewage works purposes, would be an element to enhance its value, because of its use for satisfactorily disposing of the effluents, as would the presence of water in large quantities, if a reservoir were contemplated. In fact, every likely item of value should be claimed for.

To the claim it is customary to add 10 per cent. of the total, in consideration of the sale being a forced one.

On receipt of the claim the authority can settle; if not, they make an offer to the claimant. Failing his acceptance, the question of the amount of compensation must be settled by either of the appointed tribunals.

Fixing the Compensation.

Should the owner or other interested party submit no claim, following the notice to treat, the authority should make an offer, and if the claimant does not accept it the compensation is assessed in the same way as if the owner having made a claim had not come to a settlement with the promoters.

The value of the land acquired is its value to its owner. Its potential value, and the purposes to which it will be put, must be considered in fixing the compensation.

In default of agreement, if the amount involved does not exceed £50 in all, i.e., for lands taken or injuriously affected (whether taken or not), it shall be settled by two justices of the peace,* who examine the parties and their witnesses on oath. The costs of the inquiry are to be left to their discretion.

Jury, or Arbitration.

Where the amount claimed or offered for land taken (with or without buildings, etc.) exceeds £50, and the interest of the claimant in the same is more than that of a yearly tenant, the compensation may be settled by arbitration or by a jury at the option of the claimant. If he does not notify in writing to the authority his desire for arbitration before they have issued their Warrant ("Petition" in Scotland) to the sheriff to summon a jury, the compensation is assessed by a jury, the members of which are summoned

* In Scotland, the sheriff or sheriff-substitute.

by the sheriff. This is an important point, through ignorance of which many a claimant has had his claim heard and settled by a jury, when, had he but known that a notification was all that was needed for its settlement by a surveyor or surveyors acting as arbitrators,* he would have given such notice to the other side. For it is at once apparent that the lack of trained, professional, and technical knowledge in a jury of twelve, "good men and true" though they be, must of necessity militate against a proper hearing and assessment of an equitable compensation, owing to their inability to approach the case in the competent manner which the parties would expect where the arbiters and the witnesses are professional men. Indeed, the bulk of the work under the Lands Clauses Consolidation Acts is specially set apart for surveyors (termed "valuators" in the Scottish Act).

Jury.

Ten days' prior notice must be given by the authority to the other party before the former issue their warrant to the sheriff to summon a jury. In this notice is to be stated what sum they are willing to give for the interest sought to be purchased, and for the damage to be sustained by the claimant owing to the execution of the works. (Here is the opportunity for the claimant to notify his desire for arbitration.)

The procedure in jury cases may be summed up as follows:—

The sheriff (or under-sheriff, or other person lawfully acting in his place)† summons a jury or twenty-four persons‡ to meet at a place not more than eight miles from the land, buildings, etc., in question, unless both parties otherwise agree. Not less than fourteen nor more than twenty-one days after receipt of the warrant, the sheriff gives notice to the authority, who in their turn give written information to the claimant§ at least ten days previous to the hearing. (A special jury may be summoned if either party wishes.)

Twelve men of those summoned are to be empanelled as the jury, any six or more of whom may, at the request of

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* Valuators and arbiters.

† Sheriff or sheriff-substitute.

‡ Twenty-five persons to be empanelled, thirteen to be drawn by ballot.

§ Notice of inquiry to be given by promoters to the other party, or his known agent.

either party, be ordered to view the place or matter in controversy; and on the like request witnesses may be called. (These are usually the leading surveyors of either side, and one or two others to substantiate their evidence as to the value or other pertinent matters, and might include other independent parties.) Oaths are administered, though this should scarcely be done because the evidence of an expert witness is, generally speaking, based on an opinion and not on fact.

Upon a jury giving a verdict (in which the sums of money to be paid as compensation for the purchase of land etc. and for damage, if any, are to be assessed separately), the sheriff gives judgment, and the verdict is signed by him.

Arbitration.

Where the claimant has exercised his option of having the compensation settled by arbitration, both he and the authority can concur in the appointment of a single arbitrator;* otherwise each party on the request of the other appoints an arbitrator. Neither party can revoke such appointment without the consent of the other, nor shall the death of either party revoke it.

If for fourteen days after request in writing the party served fails to appoint an arbitrator, the party making the request may appoint his arbitrator to act alone, and he shall forthwith hear and determine the matter, and his decision shall be final.

Before two arbitrators enter on the reference (i.e., the arbitration) they have to appoint an umpire† in writing to whom the case must be referred if they disagree. If they do not do so for seven days after request of either party, the Board of Trade‡ may do so. If the award of the arbitrators is not made within twenty-one days, or such extended time not exceeding three months as they may appoint, the matters then go before the umpire.† Both arbitrators and umpire may call for such documents as they or he deem necessary, and examine witnesses on oath.

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* Arbiter.

† Oversman.

‡ Lord Ordinary to appoint oversman when arbiters fail to do so. No declaration by arbiter or oversman is provided for.

The award* (in writing) is delivered to the authority promoting the undertaking, who retain the same; but on demand by the claimant they must at their expense furnish a copy to the other party to the arbitration, who may also inspect the award.

Costs.

All the costs of and incident to the arbitration shall be borne by the authority unless the award is for the same or a less sum than was offered by the authority for the claimant's interest, in which case each party has to bear his own costs and half the costs of the arbitration.†

The same rules as to costs prevail in jury cases. The costs in either jury or arbitration shall, if either party so require, be taxed and settled as between the parties by one of the masters of the Supreme Court, under Section 1 of the Lands Clauses (Taxation of Costs) Act, 1895.

Unforeseen Depreciation in Property.‡

It is of not infrequent occurrence that damage is found to be caused to property belonging to the same owner as that which has been taken, the happening of which was

* Decreet arbitral, or Award.

† In all cases the expenses of the arbiters or oversman, as the case may be, and of recording the Decreet Arbitral, or Award in the Books of the Council and Session, shall be borne by the promoters.

‡ Incorporation of Section 6 of the Railway Clauses (Scotland) Act, 1845, with the Lands Clauses (Scotland) Act, 1845.—By sec. 4 (a) of the Public Health (Scotland) Act, 1897, any reference to railways or work, in the Railway Clauses Consolidation (Scotland) Act of 1'845, means " the construction of any works under this Act, or the acquisition of rights and powers in relation to *sewers*," and references to lands taken for the railway, shall mean and include lands, buildings, engines, materials, or apparatus purchased, taken on lease, or used for the purposes of this Act."

This was necessitated, as is mentioned elsewhere, by the omission in the Lands Clauses (Scotland) Act, 1845, to provide for cases of " injurious affection," by the execution of the particular work, where no land was " taken " from the owner of that affected.

With the necessary modifications, Sec. 6 of the Railway Clauses Consolidation (Scotland) Act, 1845, reads as follows :

" In exercising the power given to the local authority by the Public Health (Scotland) Act, 1897, or by any Order or Provisional Order made in terms thereof " (under Sec. 145 (ii.) of the 1897 Act) " to construct any works under the said Act, and to take lands for that purpose, the local authority shall be subject to the provisions not contemplated when negotiation or litigation was in progress. Also it may happen that though no part of a property may be acquired, it will prove later that its value has been depreciated consequent on the execution of the work involved in the undertaking. The use to which it is put may also enter into the question, and in both examples the depreciation in value should be the basis of the claim, the annual loss being capitalized.

In such cases the injured party should serve a claim on the authority. If it does not exceed £50 it will be settled by justices (in Scotland the sheriff), as previously shown; otherwise, when making his claim the claimant should state if he wishes the matter settled by arbitration or a jury.

Mortgaged Lands.

Where any land acquired for the purpose of the undertaking is subject to mortgage,* the authority may pay the mortgage money and interest due, together with six months' further interest, or give the mortgagee† six months' notice of their intention to pay it off at the expiration of that time. If he is not in possession of the land or property in question,

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and restrictions contained in this Act and in the said Lands Clauses Consolidation (Scotland) Act, 1845; and the local authority shall make to the owners and occupiers of, and all other parties interested in, any lands, buildings, engines, materials, or apparatus purchased, taken on lease, or used for the purposes of the 1897 Act, *or injuriously affected* by the construction of any works, under the said 1897 Act, or the acquisition of rights and powers to make sewers, or to use any sewer, full compensation for the value of the lands, buildings, engines, materials, or apparatus so purchased, taken on lease, or used, and for *all damage sustained by such owners, occupiers and other parties*, by reason of the exercise, as regards such lands, buildings, engines, materials or apparatus of the powers by this or the 1897 Act, or any Order or Provisional Order made in terms thereof, or any Act incorporated therewith, vested in the local authority, and except where otherwise provided by this or the 1897 Act, or any Order or Provisional Order made in terms thereof, the amount of such compensation shall be ascertained and determined in the manner provided by the said Lands Clauses Consolidation Act for determining questions of compensation with regard to lands purchased or taken under the provisions thereof; and all the provisions of the said last-mentioned Act shall be applicable to determine the amount of any such compensation, and to enforcing the payment or other satisfaction thereof."

* Security. † Holder of Security.

the mortgagor is entitled to compensation for the value of his interest—the equity of redemption.

It may happen that the mortgage exceeds the value of the security, due to an over advance or to depreciation in the security. In such a case an agreement may be come to between the mortgagor and mortgagee on the one side, and the authority on the other, and, failing such agreement, settlement is by arbitration or a jury as previously set out, and the amount so settled is payable to the mortgagee.

If the land taken comprises only a portion of that forming the security for a mortgage, and it is of less value than the money advanced on the whole, the value of the portion taken, together with any compensation for the severance, is to be settled as mentioned above, and a memorandum is to be endorsed on the mortgage deed and signed by the mortgagee, to a copy of which the mortgagor is entitled at the expense of the authority.

If, upon payment or tender to any such mortgagee of the amount of the value or compensation, he fails to convey or release his interest to the promoters, or fails to adduce a good title, the promoters have to pay the money into the Bank, and convey the property to themselves by a deed-poll.*

Copyholds (in England and Wales).

Every conveyance of copyhold lands to the promoters must be entered on the court rolls and enfranchised by them within three months after the enrolment. Where part only of the land subject to a copyhold rent is taken, its apportionment may be settled by agreement between the owner of the lands and the lord of the manor on the one part and the promoters on the other part, and in default of settlement, then the same shall be settled by two justices. Where "common" or "waste lands" are concerned, the compensation in respect of the right in the soil, subject to any "rights of common," shall be paid to the lord of the manor if entitled, or to such party, other than the commoners, so entitled. The lord of the manor or other party entitled shall convey such lands to the promoters who in default shall have the same powers of executing a deed-poll as before provided. As regards the interest of the

* Notorial instrument.

commoners in the soil as well as to compensation for the commonable and other rights, it shall be settled by a committee, not exceeding five in number, chosen by the commoners, who shall enter into an agreement with the promoters. Failing this, the compensation is to be settled by a surveyor to be appointed by two justices, as hereinbefore provided in the case of parties who cannot be found.

Rent-charge on Land.

If a part only of any particular land which is liable to any rent-charge, rent service, or any other payment or encumbrance,* is acquired, then the charge is apportioned, by agreement between the person so entitled and the owner of the land on the one side and the authority on the other. Should such parties fail to agree, then the decision has to be made by two justices† of the peace.

Where the whole of the land subject to a particular charge is acquired, the consideration to be paid for the release of the land from such encumbrance is to be settled by agreement between the owner of the charge and the authority. Failing agreement, if the amount be under £50, the compensation can be fixed by two justices†; if over such sum, by arbitration or a jury in the manner previously set out.

Compensation to Lessees or Tenants.

Where a portion only of lands under a lease‡ with or without buildings is taken, the lessee will of course be entitled to compensation, and must submit a claim for damage sustained by him (1) by reason of the severance of land in his occupation; or (2) otherwise by reason of the execution of the works.

The rent will also require apportionment. This is done by agreement between lessor and lessee on the one part and the authority on the other; and, failing agreement, by two justices of the peace. §

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* Promoters need not redeem feu duty, ground annual, casualty of superiority, or recurring payment or incumbrance, provided they pay same when due, and otherwise fulfil all obligations.

† Sheriff or sheriff-substitute.

‡ Lease includes missive of lease or grant.

§ Sheriff or sheriff-substitute.

Where the whole of the holding is acquired, the occupier will be entitled to compensation for full damages, assessable by arbitration or a jury.

An occupier having a greater interest in the land than a yearly tenancy, must show his lease within twenty-one days from the demand of the authority acquiring the land or other property requesting its production; otherwise he will be treated as a yearly tenant, and only entitled to compensation accordingly.

If an occupier has no greater interest than a yearly tenancy, or for a year, if he is required to surrender his holding before the expiration of his interest, he is entitled to receive compensation for its value; also an equitable allowance which would have been made to him by an incoming tenant; and further compensation for any loss or injury which he may sustain consequent upon the acquisition of the property by the promoters. In each case he must claim accordingly.

Should a part only of the land in his occupation be acquired, the items for compensation are: damage due to the severance, and for injurious affection (if any).

Unascertainable Owner.

It occasionally happens—and not so infrequently as one might suppose—that the owner of a certain piece of land or premises cannot be ascertained by the authority. In such a case, after they have exhausted all means of ascertaining, application has to be made by them to justices* to appoint a surveyor† to determine the compensation; and the sum he fixes is to be deposited in the Bank of England or Ireland‡, to be paid out to the person or persons (if any) proving ownership. The procedure is similar where the known owner of land happens to be absent from the country.

In both cases (i.e., if the unknown owner proves ownership, or on the return of the absent one), if the owner is dissatisfied with the surveyor's valuation, he can, before applying to the High Court (or equivalent Court in Ireland or Scotland) for the payment of the money deposited in the Bank, give written notice to the authority to that effect, whereupon the amount to which he is entitled is to be

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* Sheriff or sheriff-substitute.

† Valuator nominated by the sheriff or sheriff-substitute.

‡ Any one of the incorporated or chartered Banks.

ascertained by arbitration in a similar manner to other arbitrations previously described.

Buying Back " Superfluous " Land.

It may happen that some portion of the land acquired compulsorily is found later not to be permanently needed for the purposes of the particular undertaking, in which case it becomes what is technically known as "superfluous." In such an event, the promoters must dispose of it within a period stated in the "special" Act (i.e., that authorizing the particular undertaking) or within ten years. Supposing the promoters omit to do so, then at the expiration of that period any such land (unless built upon or used for building purposes) is to become the property of the owners of the adjoining lands.

But assuming the usual procedure in such cases is adopted, the promoters have to follow a particular method involving what is known as the right of pre-emption. By it the land in question has first to be offered to the person from whom it was originally acquired; if he refuses to purchase it then to the owner or the several owners whose lands all immediately adjoin the superfluous land. Where there is more than one person so entitled, such offer is to be made to each owner in succession, in such order as the promoters think fit.

A period of six weeks is to be given in these circumstances to each of the owners to whom the offer is made to decide whether he will take advantage of the opportunity offered him or not.

If one of them elects to purchase, he should inform the promoters of his intention. The price at which the land in question is to be transferred can then be settled by agreement between the promoters and himself; but if a sum cannot be so agreed upon, the amount must be fixed by arbitration only.

Failing the exercise of this right of pre-emption by anyone so entitled, the land may be sold to any person or persons, as the authority think fit.

Owners and " Special " Act.

In all cases where land is to be acquired for the carrying out of any particular undertaking under special powers, the owner or occupier of land to be affected thereby should obtain a copy of the "Special" Act, i.e., the Act authorising the carrying out of the undertaking and the acquisition under compulsory powers of the particular lands and buildings involved. He would also do well to obtain advice upon it if any point seemed difficult to understand.*

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* Lands in Commonty, etc. (Scotland).—The promoters may convene a meeting of the parties entitled to any rights of property or servitude, etc., in or over lands to be acquired. Such meeting is to be held at some convenient place in the neighbourhood of the lands, and is for the purpose of the interested parties appointing a committee to treat with the promoters, for the amount of compensation to be paid for the extinction of their rights. The meeting shall be called by advertisement, inserted once, at least, for two consecutive weeks, in some newspaper circulating in the county or in the respective counties (if more than one) in the neighbourhood in which such lands are situated, the last of such insertions being not more than fourteen nor less than seven days prior to such meeting. Further, not less than seven days' previous notice must be affixed upon the door of the parish church where such meeting is ntended to be held, or, if no church, on some other place in the neighbourhood to which notices are usually affixed; and if such ands form part of a barony a like notice shall be given to the superior or baron.

A committee, not exceeding five in number (if there be so many as five entitled to such rights), is to be appointed by a majority of those present who are legally entitled to take part in such election. Such committee may agree with the promoters upon the sum to be paid to the interested parties for the extinction of the rights, and they may receive the money and apportion the same among the several interested persons, according to their respective interests, but the promoters shall have no responsibility as regards the apportionment. Any three members of the committee may sign the receipt given to the promoters in respect of the compensation money.

Failing agreement between the promoters and the committee, the compensation is to be settled as in other cases where the amount of compensation is disputed. If no committee is appointed, the amount is to be fixed by a valuator appointed by the sheriff or sheriff-substitute, as in the case of parties who cannot be found.

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